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UNITED STATES DEPARTMENT OF AGRICULTURE

DEPARTMENT BULLETIN No. 1472

Washington, D. C. ▼ March, 1927.

CHEMOTROPIC TESTS WITH THE SCREW-WORM FLY

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CONTENTS

INTRODUCTION

Throughout the southwestern part of the United States heavy losses are suffered each year by the various livestock interests owing to the destructive activities of blowflies. Although the farmers and dairymen have considerable trouble with these insects, the losses are most severely felt by the cattle, sheep, and goat raisers on the ranges.

The species commonly known as the screw-worm fly, *Cochliomyia macellaria* Fab., is by far the most destructive of the blowflies. The average annual loss due to this insect has been estimated at $4,000,000. It breeds normally in dead or living animal tissue. When the flies are abundant they are strongly attracted to the slightest scratch or blood spot on the skin of an animal. Under favorable conditions oviposition takes place, and the larvæ hatch and start feeding on the living tissues of their host. The larger the wound the more attractive it becomes, and the infestation continues to increase, resulting in extensive destruction of tissue and very often the death of the animal if treatment is not administered within two or three days.

[1] Died June 19, 1923. Since May, 1924, R. C. Roark has been the representative of the Bureau of Chemistry in this investigation.

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Certain other species of flies, such as the black blowfly, *Phormia regina* Meig., the green bottle flies *Lucilia sericata* Meig. and *L. cuprina* Meig., and some species of sarcophagids, particularly *S. robusta* Ald., not infrequently infest wounds, but they are much less important than the screw-worm fly. The black blowfly is more inclined to attack old suppurating sores and is most abundant during cool weather, hence it commonly infests animals after dehorning. It also attacks sheep in the early spring, laying its eggs on soiled wool. In this situation it is commonly spoken of as the "wool maggot."

For the control of these blowflies several methods are commonly used. These are (1) the destruction of carcasses in which the flies breed; (2) the prevention of wounds, such as wire cuts, scratches, and bruises, by careful handling at the times when the animals are rounded up, dipped, etc.; (3) the carrying out of the castrating, branding, dehorning, and shearing of animals at times when flies are scarce or absent; (4) the trapping of adult flies in traps baited with meat, or, preferably, dried-egg bait; (5) the use of larvicides and repellents on infested wounds on animals.

WORK OF OTHER INVESTIGATORS WITH FLY REPELLENTS

Although the chemotropic responses of many insects have been studied, only a few investigators have experimented with blowflies, and no reference to previous work with repellents for the screw-worm fly has been found.

Cooper and Walling [2] tested the effect of various chemicals upon blowflies (Calliphora) by dusting pieces of meat with a number of different materials incorporated in precipitated chalk. The authors concluded that the following were most suitable as repellents: Methyl salicylate, para-nitraniline, picric acid, creosote, green oil, boracic acid, fusel oil, pine oil, alizarine oil, origanum oil, mustard oil, sod oil, iodoform, dimethylaniline, quinoline, allyl alcohol, aloin, saponin, copper carbonate, nitrobenzene, sinapis oil, and anise-seed oil.

Olive C. Lodge [3] reported on some studies of attractive substances which might be used as baits for blowflies and house flies. She found liver to be more attractive than a number of other animal tissues and brought out the fact that the infestations of baits with larvæ caused the baits to become more attractive to the flies. She mentions among the substances showing decided repellent qualities for one species of blowfly (*Protophormia terrae-novae* R. D.), pipendine [piperidine?], oenanthol, xylol, amyl acetate, methyl salicylate, anisole, citral (strong), ethyl sulphocyanide, oil of thyme, of cassia, of Java citronella, of palma rosa, of bay, of heliotrope, of lavender, of cinnamon leaf, of cinnamon bark, of sassafras, of cloves, of camphor. Many other substances tested by her are classed as less repellent or neutral. She also conducted some tests with Calliphora and Lucilia.

Wardle [4] tested the repellent effect upon blowflies (Calliphora) of various materials by rubbing them upon cotton twine netting of

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[2] COOPER, W. F., and WALLING, W. A. B. THE EFFECT OF VARIOUS CHEMICALS ON BLOW-FLY. Ann. Appl. Biol. 2: 166–182. 1915.

[3] LODGE, O. C. FLY INVESTIGATIONS REPORTS. IV. SOME ENQUIRY INTO THE QUESTION OF BAITS AND POISONS FOR FLIES, BEING A REPORT ON THE EXPERIMENTAL WORK CARRIED OUT DURING 1915 FOR THE ZOOLOGICAL SOCIETY OF LONDON. Zool. Soc. London, Proc. 1916: 481–511. 1916.

[4] WARDLE, R. A. THE PROTECTION OF MEAT COMMODITIES AGAINST BLOWFLIES. Ann. Appl. Biol. 8 1–9. 1921.

quarter-inch diamond mesh. This netting was tied over the opening of cylindrical glass dishes containing food samples. Oil of star anise was effective in preventing the food from being blown for 24 hours; samples protected with eucalyptus oil, formic acid, and sometimes clove oil remained untouched for 12 hours, while samples protected by oil of almonds, oil of citronella, oil of cinnamon, boracic acid, picric acid, or nitrobenzene were blown within 6 hours.

MATERIALS NOW USED AS SCREW-WORM FLY REPELLENTS

Pine tar, tannic acid, turpentine, kerosene, gasoline, various sheep and cattle dips, hydrated lime, calomel, and other materials have been used in the past with more or less success.[5] Many home remedies, such as axle grease and lampblack are used by ranchmen, but probably proprietary "screw-worm killers" of one sort or another are now most prevalently used. These consist largely of crude carbolic acid, which, though efficacious in killing all fly larvæ with which it comes into contact, is also very poisonous to animals. As a result, many animals are killed by the treatment. In addition, many ranchmen hesitate to use these carbolic preparations upon their fine stock and confine themselves to the use of chloroform or other larvicides. Although chloroform is in extensive use for killing fly larvæ in wounds, it has no repellent value and does not prevent reinfestation.

The cost of treating an animal for screw-worm infestation has been estimated by several ranchmen to be from 25 to 50 cents for each treatment. A conservative estimate would be 25 cents for each treatment, or $25 per 100 infested animals per day when treatments are required from once to twice daily. Repeated treatments by improper methods and successive worm infestations occasionally necessitate the treatment of the cases for months.

PURPOSE OF CHEMOTROPIC TESTS

The purpose of this study has been to find a material that will prevent reinfestation for 48 hours or longer. This would relieve the situation to a great extent, as it is not uncommon to find as many as 400 to 500 cases of worms on a single ranch in seasons favorable for the screw worm, and a considerable number of cases on most ranches every season.

The problem involves two objects to be accomplished through the treatment of wounds: (1) The destruction of the larvæ if present, and (2) the protection of the wound from infestation for a reasonable length of time. It is obvious that any treatment which will injure the tissues so as to delay healing or which will act as a local or systemic poison, will defeat the ends in view.

The experience of the writers indicates that there is considerable difficulty in successfully combining a larvicide and a repellent to be used as a single treatment, as the killing properties of the larvicides are too much reduced by the admixture of the repellent material. Hence it is logical to attempt to develop a strong and lasting repellent without larvicidal action.

In this bulletin, therefore, the data given deal essentially with the question of the chemotropic responses of the screw-worm fly to various

[5] BISHOPP, F. C., MITCHELL, J. D., and PARMAN, D. C. SCREW-WORMS AND OTHER MAGGOTS AFFECTING ANIMALS. U. S. Dept. Agr. Farmers' Bul. 857, 19 p., illus. 1919. (Revised, 1922.)

materials, and contain only incidental information on the toxicity of these materials to the eggs, larvæ, or adults.

From a practical point of view there are a number of factors which must be considered. Among these are availability of the materials, their cost, adhesive qualities, suitability for handling, stability or keeping qualities, whether they stain wool or mohair, and the effect on the animal tissues, which has already been mentioned. Some may feel that the value of a repellent for use on living animals can not be determined by tests conducted with dead tissue. It seemed to the writers, however, that a determination of the reaction of flies toward a large number of materials, exposed under observable conditions, would give, with a minimum expenditure of time and money, the basic information upon which to proceed with other studies. This assumption is being justified by work now in progress. The various practical points mentioned above will be considered in connection with a subsequent report on the treatment of livestock and other uses to which repellents are commonly put. Some of the results of field tests with repellents have been presented.[6]

There are many other uses to which repellents may be put. For instance, there is considerable loss from the infestation of foods by flies, aside from the danger of disease being conveyed to man through eating foods contaminated by them. Throughout the South, and even in the cooler parts of the country, it is often difficult to dress meat on the farm or range or even in well-equipped slaughter houses without having it "blown" by flies. Slaughtering at night, the use of smudges, and other means of avoiding this are practiced, but with only partial success, whereas a good repellent would largely solve the difficulty. Again, tourists and picnic parties are often greatly annoyed and their foods contaminated so as to render life outside of screened houses well-nigh unbearable. The use of an effective repellent under such conditions has been found of great value. Such repellents would serve a useful purpose about the household, dairy, and all establishments where foods are handled or displayed.

Another, though somewhat different, phase of this subject is the use of repellents to protect livestock of all classes from annoyance by flies, especially the blood-sucking forms, such as the horn fly, stable fly, and buffalo gnat. Although this particular series of experiments does not consider, directly, this use of repellents, it is thought that the information gained will aid materially in this field; in fact, the data have already furnished valuable clues which are being followed in the work now under way with sprays for flies on livestock.

This bulletin presents the results of jar tests with the screw-worm fly, *Cochliomyia macellaria* Fab. The results of the tests with the house fly, *Musca domestica* L., the green bottle flies, *Lucilia* spp., and other species will be presented in subsequent papers.

MATERIALS TRIED

As very few observations on the chemotropic responses of blowflies to various chemicals have been recorded heretofore, the materials used in these tests were selected from a wide range of organic and inorganic compounds in order to reconnoiter the whole field of possible

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[6] LAAKE, E. W., PARMAN, D. C., BISHOPP, F. C., and ROARK, R. C. FIELD TESTS WITH REPELLENTS FOR THE SCREW-WORM FLY, COCHLIOMYIA MACELLARIA FAB., UPON DOMESTIC ANIMALS. Jour. Econ. Ent. 19: 536–539. 1926.

practical repellents. Representatives of the different classes of the more common and easily procurable organic compounds were selected. The formulæ and boiling points of these are shown in Table 1 with the purpose of ascertaining whether or not there is a relation between the repellent action of organic compounds and their chemical constitution and their volatility (which is measured roughly by their boiling points). On account of the widespread use of certain essential oils, especially citronella and pennyroyal, as mosquito repellents, many tests were made with these. Fish oil, pine tar, and turpentine have been recommended for use in keeping flies off dairy cattle, and it was thought worth while to subject these to careful tests also.

The lubricating oil referred to in the table was automobile motor oil, specific gravity 0.930, Saybolt viscosity at 104° F. 495, manufactured from crude oils of different bases; petrolatum was U. S. P.; the petroleum was north Texas crude which consists principally of paraffin oils. The mineral oil referred to in a few tests was a spindle oil with a specific gravity at 60° F. of about 0.88 and boiling range from 569 to 750° F. Most of the chemical compounds were chemically pure and the essential oils and crude drugs were of the best commercial grade.

PROCEDURE

In some preliminary tests fresh meat was exposed on paper plates in places where flies were abundant, and the materials, the repellent values of which were to be tested, were sprayed with a hand atomizer over the meat until the latter was well covered. About one-half pound of fresh beef was used to each plate. This method proved unsatisfactory, as the number and species of flies present could not be determined accurately.

The baits were next placed in small cone flytraps, but when determination of the flies was made frequently this method was found to be very cumbersome.

The next procedure was to put into a pint Mason jar enough sand to make a layer 1 inch in depth, place 4 ounces of fresh meat on the sand, and then spread a measured quantity of the repellent over the surface of the meat. Rabbit meat was used in some of the tests, but as a rule fresh beef liver was employed. It was found that 5 cubic centimeters of the liquid repellents sufficed to thoroughly cover the meat, and all the tests were accordingly made with this quantity. In the case of the solid materials, 5 grams were used. Since the densities of the liquids differed considerably, the same quantity by weight was not used in the different tests, and in only a few cases did 5 cubic centimeters equal 5 grams. However, for a rapid survey of the field of possible repellents these differences are negligible.

As a rule, each repellent was tested in duplicate at the same time. A series of 30 to 40 jars would be prepared, 2 of which (sometimes 3 to 5) were left untreated and served as checks. The meat in the other jars was covered with the materials to be tested, and the series of jars exposed in a favorable environment where flies were plentiful. Identical tests were made in Dallas and in Uvalde, Tex. In Dallas the jars were exposed in a large roofed shed in the yard of a large packing plant, and were usually first set out about noon. The distance between jars varied from 4 to 6 feet. Observations were

made at two-hour intervals as to the number of each species of fly within the jars. Two observations were made on the day of setting out the jars, four each on the second, third, and fourth days of exposure, and two observations on the fifth and last day of exposure, making 16 observations in all. At the end of each observation period the jars were interchanged in position so as to equalize the conditions of shade and sunlight as much as possible. In Uvalde the jars were set out on the ground in the partial shade of mesquite trees, and examined as described above. The results at the two stations, Dallas and Uvalde, are similar, and in summarizing the data no distinction has been made as to locality.

In this series of experiments no attempt has been made to determine how the meat was rendered unattractive to the flies. It is certain, however, that what has been spoken of as repellent action is a very complicated matter. It is evident that the meat in these tests was protected in several ways by different materials. In some cases the protection was largely mechanical, either by covering the attractive surface or searing the surface so as to denature the meat and stop decomposition; in other cases it was brought about by masking the attractive odor of the baits; and in still others it was due either to a negative chemotropic response on the part of the fly through the sense of smell or an irritation response through the respiratory tract or elsewhere.

METHOD OF COMPUTING RESULTS

The repellent value of a material is determined by the ratio of the number of flies visiting treated meat to the number visiting untreated meat. Owing to the great variation in the prevalence of flies from week to week, several tests made at different times are necessary to accurately gauge the repellent value of any material. In summarizing these data on repellent action the number of flies of the same species visiting all jars treated with the same repellent has been used, and the ratio between this number and the number of flies visiting a comparable number of untreated or check jars has been determined. For example, if the ratios in several tests made at different times are 8/119, 23/97, 19/207, these are combined into the single ratio 50/423. In this way the observations are weighted according to the abundance of flies, as indicated by the number of flies visiting the untreated meat.

The percentage ratio as given is therefore not the percentage of repellent efficiency directly, but is the percentage of flies entering the treated jars as compared with the number entering the corresponding checks; that is, a percentage ratio of 0 indicates perfect repellent action, 100 shows no effect of the material, and over 100 indicates that the material is attractive.

The percentage ratios for the daily periods have not been computed, but the actual number of flies visiting the jars on each day is given. The figures for the first day really represent only one afternoon, as the tests were usually begun about midday; and the figures for the fifth day usually cover only the forenoon of the last day of exposure, as the tests were usually terminated at noon. It is believed that some idea of the duration of repellent effect may be gained from the comparison of the number of Cochliomyia adults

entering the treated and check jars each day, as expressed in the daily ratios.

It was observed in the course of the experiments that when the baits in the check jars became very heavily infested by larvæ, as was often the case, their attractiveness diminished toward the end of the period of exposure and was sometimes completely lost. This tended to place the jars which were treated with a more or less effective repellent, and hence not infested, at a disadvantage when compared with the unattractive check during the last day or two of the test.

In addition to observations of the number of each species of fly present in the jar at two-hour intervals, observations were made as to the presence of eggs or larvæ. The degree of infestation was observed to vary greatly, as indicated by the number of egg masses deposited and the number of larvæ which were present in the different jars at the close of each test. As no effort was made to determine the actual number of eggs deposited, the results are reported as number of infested treated jars over number of infested check jars. Furthermore, since it is impossible by a cursory examination to determine the species of egg or larva, these infestation figures apply to all species, except perhaps the house fly, which infests fresh meat so little that it can be neglected. The species responsible for the infestation was determined by transferring the eggs or larvæ in the jars at the end of the five-day test period to fresh meat and allowing the adults to emerge in screened cages. The emergence data are shown by giving the number of treated jars from which they emerged, no account being taken of the number of flies bred out. The emergence data are incomplete, owing to the difficulties inherent in handling so much material and to the escape of larvæ from the cages.

The fact is recognized that the tests of many of the materials are insufficient both as regards the number of flies present when the tests were conducted and the variety of conditions, such as climatic conditions or dilution of materials, under which a given material was exposed. These matters have been given some consideration in the "Discussion of results," p. 22.

TABULAR STATEMENT OF RESULTS OF TESTS

The results of the chemotropic tests with screw-worm flies are presented in Table 1.

TABLE 1.—*Results of chemotropic tests with Cochliomyia macellaria*

[Number of Cochliomyia flies visiting jars containing treated meat as compared with untreated meat during five days' exposure, together with number of treated jars infested over number of check jars infested for each day, and the number of treated jars from which Cochliomyia flies emerged over the number of check jars from which they emerged]

Compound	Formula	Boiling point	Total number of treated jars	Total number flies, treated jars over checks	Percentage ratio for entire period	Ratio for flies visiting jars					Ratio for infestation					Ratio for emergence
						First day	Second day	Third day	Fourth day	Fifth day	First day	Second day	Third day	Fourth day	Fifth day	
Hydrocarbons:		° *C.*														
Lubricating oil			4	18:46	39	0:19	5:10	5:0	6:17	2:0	0:2	1:2	1:2	2:4	2:4	0:2
Petrolatum			6	1, 659:1, 085	153	3:185	1, 468:774	162:123	22:3	4:0	1:4	4:6	4:6	4:6	4:6	1:3
Petroleum			2	879:505	174	0:0	8:22	390:7	407:443	74:33	0:1	2:2	2:2	2:2	2:2	2:2
Benzene	C_6H_6	79.6	2	365:520	70	18:90	199:288	52:84	89:56	7:2	1:1	1:2	2:2	2:2	2:2	2:2
Toluene	$C_6H_5CH_3$	110.5	6	120:176	68	50:21	65:148	5:7	0:0	0:0	1:5	2:6	2:6	2:6	2:6	0:0
Toluene (1) plus petrolatum (5).[1]			2	0:5	0	0:0	0:3	0:2	0:0	0:0	0:2	0:2	0:2	0:2	0:2	0:0
Ortho-xylene	$C_6H_4(CH_3)_2$	144	3	100:213	47	47:62	40:104	4:45	3:2	6:0	2:2	3:3	3:3	3:3	3:3	0:1
Naphtha, crude solvent (90% xylene).			4	26:117	22	5:13	21:97	0:7	0:0	–:–	2:4	2:4	2:4	2:4	2:4	0:0
Para-cymene	$CH_3C_6H_4CH(CH_3)_2$	176	7	348:751	46	94:479	180:233	74:32	0:7	–:–	5:7	6:7	6:7	6:7	6:7	1:1
Naphthalene	$C_{10}H_8$	217.9	4	13:20	65	3:3	7:13	3:4	0:0	0:0	0:4	2:4	2:4	2:4	2:4	0:0
Anthracene	$C_6H_4(CH_2)_2C_6H_4$	342	3	0:18	0	0:0	0:0	0:0	0:18	0:0	0:0	0:1	1:1	1:3	1:3	0:2
Anthracene oil			2	48:101	47	17:10	31:86	0:5	0:0	–:–	1:2	2:2	2:2	2:2	2:2	2:–
Alpha-pinene	$C_{10}H_{16}$	154	5	399:692	58	230:471	126:182	43:32	0:7	–:–	2:4	2:5	2:5	2:5	2:5	0:1
Bromides:																
Bromoform	$CHBr_3$	150.4	7	499:975	51	18:49	331:380	111:319	34:205	5:22	1:4	3:7	7:7	7:7	7:7	0:3
Bromoform (1) plus kaolin (4).			1	1:88	1.1	0:17	0:25	0:41	1:4	0:1	0:0	1:1	1:1	1:1	1:1	–:0
Ethylene bromide	$CH_2Br.CH_2Br$	131.7	2	8:29	28	4:19	3:10	1:0	0:0	0:0	1:2	2:2	2:2	2:2	2:2	0:–
Benzyl bromide	$C_6H_5CH_2Br$	199	1	1:1	100	0:0	1:0	0:0	0:1	0:0	0:0	0:1	0:1	0:1	0:1	–:0
Para-xylyl bromide	$CH_3C_6H_4CH_2Br$	220.7	4	1:617	0.2	0:1	0:15	0:215	0:315	1:71	0:0	0:0	0:2	0:4	0:4	0:4
Para-xylyl bromide (1) plus lubricating oil (9).			2	62:17	365	2:0	57:0	2:0	1:17	0:0	0:0	1:0	1:0	1:2	1:2	0:2
Para-xylyl bromide (1) plus lubricating oil (99).			2	52:17	306	3:0	43:0	0:0	0:17	6:0	0:0	0:0	0:0	1:2	1:2	0:2
Alpha-bromonaphthalene.	$C_{10}H_7Br$	281.1	5	67:941	7.1	8:130	10:388	16:274	25:127	8:22	0:3	0:5	3:5	5:5	5:5	0:3
Chlorides:																
Chloroform	$CHCl_3$	61.2	1	295:154	192	150:54	89:53	13:45	16:2	27:0	1:1	1:1	1:1	1:1	1:1	0:1
Carbon tetrachloride	CCl_4	76.8	1	94:154	61	44:54	9:53	27:45	9:2	5:0	1:1	1:1	1:1	1:1	1:1	1:1
Hexachloroethane	C_2Cl_6	185	2	16:154	10	0:5	0:65	6:72	8:11	2:1	0:1	2:2	2:2	2:2	2:2	1:1
Benzyl chloride	$C_6H_5CH_2Cl$	179.4	4	5:617	.8	0:1	0:15	2:215	2:315	1:71	0:0	0:0	0:2	0:4	0:4	0:4

Benzyl chloride (1) plus lubricating oil (9).			2	14:17	82	0:0	11:0	1:0	2:17	0:0	0:0	0:0	0:0	0:2	0:2	0:2
Para-xylyl chloride	$CH_3C_6H_4CH_2Cl$	202	4	101:617	16	0:1	4:15	7:215	86:315	4:7	0:0	0:0	0:2	2:4	2:4	0:4
Para-xylyl chloride (1) plus lubricating oil (9).			2	3:17	18	0:0	0:0	2:0	1:17	0:0	0:0	0:0	1:0	1:2	1:2	0:2
Para-dichlorobenzene	$C_6H_4Cl_2$	173	9	380:464	82	23:11	51:118	193:243	93:92	20:0	1:6	4:9	7:9	8:9	8:9	2:3
Chlorinated naphthalene.			2	3:5	60	3:0	0:3	0:2	0:0	0:0	2:2	2:2	2:2	2:2	2:2	0:0
Pinene plus hydrochloric acid.			5	212:495	43	20:298	104:192	88:5	0:0	-:-	3:5	5:5	5:5	5:5	5:5	0:2
Turpentine plus hydrochloric acid.			4	66:161	41	1:18	65:138	0:5	0:0	-:-	1:4	4:4	4:4	4:4	4:4	0:2
Camphor, artificial (pinene hydrochloride).	$C_{10}H_{17}Cl$	207.4	1	1:366	.3	0:36	1:234	0:40	0:55	0:1	0:0	0:1	0:1	0:1	1:1	0:1
Pinene hydrochloride in benzene (saturated solution).			3	154:277	56	91:221	60:55	3:1	-:-	-:-	3:3	3:3	3:3	3:3	3:3	0:0
Iodides:																
Iodoform	CHI_3	sub.	4	76:1,116	6.8	7:108	58:510	2:246	5:230	4:22	2:2	3:4	4:4	4:4	4:4	0:4
Iodoform (1) plus kaolin (4).			1	12:455	2.6	0:64	10:354	2:37	0:0	0:0	0:0	1:1	1:1	1:1	1:1	0:1
Iodoform (1) plus petrolatum (2).			1	3:455	.7	0:64	2:354	1:37	0:0	0:0	0:0	0:1	1:1	1:1	1:1	0:1
Iodoform (1) plus petrolatum (5).			2	1:5	20	1:0	0:3	0:2	0:0	0:0	1:2	1:2	1:2	1:2	1:2	0:0
Alcohols:																
Denatured alcohol (ethyl alcohol plus methyl alcohol).			2	693:600	116	0:1	35:15	235:215	266:298	157:71	0:0	0:0	0:2	1:2	2:2	2:2
Fusel oil (amyl alcohol)			1	5:14	36	0:1	1:8	4:5	-:-	-:-	0:1	0:1	1:1	1:1	1:1	-:-
Glycerin	$CH_2OHCHOHCH_2OH$	290	2	44:59	75	7:8	37:51	0:0	0:0	-:-	1:1	1:2	1:2	1:2	1:2	-:-
Geraniol	$C_9H_{15}CH_2OH$	229	4	325:581	56	86:132	66:307	59:84	55:56	59:2	3:3	4:4	4:4	4:4	4:4	4:4
Linalool	$C_{10}H_{17}OH$	198.3	1	35:82	43	0:4	15:40	17:31	3:7	-:-	0:0	1:1	1:1	1:1	1:1	0:1
Dextro-borneol	$C_{10}H_{17}OH$	213.5	3	56:428	13	12:78	11:254	12:40	9:55	12:1	2:2	3:3	3:3	3:3	3:3	1:3
Dextro-borneol in alcohol (saturated solution).			8	639:771	83	261:485	298:280	61:6	19:0	-:-	5:8	5:8	6:8	6:8	6:8	5:-
Alpha-terpineol	$C_{10}H_{17}OH$	219.8	2	19:154	12	0:5	4:65	13:72	2:11	0:1	0:0	0:2	2:2	2:2	2:2	1:2
Menthol	$C_{10}H_{19}OH$	212	3	386:394	98	179:288	145:106	62:0	-:-	-:-	3:3	3:3	3:3	3:3	3:3	0:2
Phenols:																
Ortho-cresol	$CH_3C_6H_4OH$	190.8	1	5:14	36	0:1	5:8	0:5	-:-	-:-	0:1	0:1	1:1	1:1	1:1	-:-
Cresol U. S. P.			5	180:624	29	87:468	86:150	7:6	-:-	-:-	1:5	2:5	3:5	3:5	3:5	0:1
Resorcinol	m-$C_6H_4(OH)_2$	276.5	1	164:455	36	1:64	146:354	10:37	7:0	-:-	1:0	1:1	1:1	1:1	1:1	1:1
Eugenol	$C_3H_5C_6H_3(OH)OCH_3$	253	9	93:507	18	11:271	71:149	10:75	1:11	0:1	2:7	7:9	9:9	9:9	9:9	1:3
Guaiacol	$OHC_6H_4OCH_3$	205.1	2	2:505	.4	0:0	0:22	0:7	0:443	2:33	0:1	0:2	2:2	2:2	2:2	0:2
Safrol	$C_3H_5C_6H_3=O_2=CH_2$	234.5	12	388:1,579	25	0:72	23:445	235:597	110:438	20:27	0:9	3:12	8:12	11:12	12:12	1:7
Safrol (1) plus mineral oil (5).			1	22:96	23	0:1	0:38	8:53	3:2	11:2	0:0	1:1	1:1	1:1	1:1	-:-

[1] Figures in parenthesis indicate the number of parts of the substance in the mixture.

TABLE 1.—*Results of chemotropic tests with Cochliomyia macellaria*—Continued

Compound	Formula	Boiling point	Total number of treated jars	Total number flies, treated jars over checks	Percentage ratio for entire period	Ratio for flies visiting jars					Ratio for infestation					Ratio for emergence
						First day	Second day	Third day	Fourth day	Fifth day	First day	Second day	Third day	Fourth day	Fifth day	
Phenols—Continued.		° *C.*														
Safrol (1) plus petrolatum (5).			1	1:96	1.0	0:1	0:38	1:53	0:2	0:2	0:0	0:1	1:1	1:1	1:1	-:-
Safrol (1) plus kaolin (4).			2	8:168	4.8	0:2	0:63	6:93	1:7	1:3	0:0	0:2	0:2	1:2	2:2	0:-
Thymol	$(CH_3)_2CHC_6H_3(CH_3)OH$.	231.8	3	61:394	16	13:288	43:106	5:0	-:-	-:-	2:3	2:3	2:3	2:3	2:3	0:2
Thymol (1) plus pine oil (5).			2	16:59	27	0:8	16:51	0:0	0:0	-:-	-:1	-:2	-:2	-:2	-:2	0:-
Thymol in benzene (saturated solution).			3	205:277	74	18:221	120:55	67:1	-:-	-:-	1:3	2:3	3:3	3:3	3:3	0:-
Thymol in alcohol (saturated solution).			2	24:101	24	7:10	10:86	1:5	6:0	-:-	1:2	2:2	2:2	2:2	2:2	0:-
Carvacrol	$(CH_3)_2CHC_6H_3(CH_3)OH$.	237.9	6	117:442	26	20:81	33:264	24:42	16:54	24:1	2:5	5:6	6:6	6:6	6:6	2:1
Aldehydes:																
Formaldehyde (40 per cent solution in water).	HCHO		7	56:349	16	24:77	31:194	1:62	0:15	0:1	5:7	6:7	6:7	6:7	6:7	0:1
Formaldehyde (1) plus petrolatum (5).			2	0:5	0	0:0	0:3	0:2	0:0	0:0	1:2	1:2	1:2	1:2	1:2	0:0
Butyraldehyde	$CH_3(CH_2)_2CHO$	75.7	4	225:357	63	0:1	9:28	162:236	47:92	7:0	1:3	2:4	4:4	4:4	4:4	1:4
Crotonaldehyde	$CH_3HC{=}CHCHO$	104	4	23:357	6.4	0:1	0:28	3:236	17:92	3:0	0:3	3:4	4:4	4:4	4:4	0.4
Heptaldehyde	$CH_3(CH_2)_5CHO$	155	5	126:358	35	0:1	9:28	75:237	25:92	17:0	0:2	1:5	4:5	4:5	5:5	1:4
Citral	$C_9H_{15}CHO$	229	2	18:101	18	4:10	12:86	2:5	0:0	-:-	0:2	1:2	2:2	2:2	2:2	0:-
Citronellal	$C_{10}H_{18}O$	208	1	37:82	45	0:4	2:40	32:31	3:7	-:-	0:1	1:1	1:1	1:1	1:1	0:1
Furfural	$C_4H_3O.CHO$	161.7	17	81:1,527	5.3	4:126	25:539	13:398	33:437	6:27	3:12	10:17	14:27	15:17	16:17	0:7
Furfural (1) plus mineral oil (5).			1	0:96	0	0:1	0:38	0:53	0:2	0:2	0.0	0:1	0:1	0:1	0:1	0:-
Furfural (1) plus petrolatum (5).			3	1:475	.2	0:67	1:306	0:41	0:1	0:0	0:2	0:3	1:3	1:3	1:3	0:1
Furfural (3) plus petrolatum (1) plus borax (1).			1	0:96	0	0:1	0:38	0:53	0:2	0:2	0:0	0:1	0:1	1:1	1:1	0:-
Furfural (1) plus kaolin (4).			4	23:640	3.6	0:69	2:427	7:133	2:8	12:3	0:2	0:4	2:4	3:4	3:4	1:1
Benzaldehyde	C_6H_5CHO	179.5	2	11:505	2.2	0:0	0:22	1.7	9:443	1:33	1:1	2:2	2:2	2:2	2:2	1:
Salicylic aldehyde	OHC_6H_4CHO	196.5	9	88:695	13	0:55	5:231	35:392	45:16	3:1	0:7	2:9	4:9	6:9	7:9	1:3
Salicylic aldehyde (1) plus mineral oil (5).			1	30:96	31	0:1	0:38	7:53	21:2	2.2	0:0	0:1	1:1	1:1	1:1	-:-

Salicylic aldehyde (1) plus petrolatum (5).			2	0:113	0	0:5	0:47	0:56	0:3	0:2	0:1	0:2	0:2	0:2	0:2	0:–
Salicyclic aldehyde (1) plus kaolin (4).			3	9:185	4.9	0:5	3:73	3:96	3:8	0:3	0:1	1:3	1:3	2:3	2:3	0:–
Salicylic aldehyde (1) plus benzene (1).			1	30:65	46	0:19	4:41	25:5	0:0	1:0	1:1	1:1	1:1	1:1	1:1	–:–
Salicylic aldehyde (1) plus benzene (1) plus alcoholic solution of gum galbanum (1).			1	44:65	68	0:19	5:41	12:5	27:0	0:0	1:1	1:1	1:1	1:1	1:1	–:–
Salicylic aldehyde (1) plus benzene (5) plus grafting wax (2).			1	44:65	68	0:19	5:41	12:5	27:0	0:0	–:1	–:1	–:1	–:1	–:1	–:–
Salicylic aldehyde (8) plus petrolatum (5) plus borax (1).			1	6:65	9.2	0:19	1:41	4:5	1:0	–:–	0:1	1:1	1:1	1:1	1:1	–:–
Cinnamic aldehyde	$C_6H_5CH=CHCHO$	248	8	194:1,195	16	0:50	11:394	87:520	81:209	15:22	0:5	4:8	7:8	8:8	8:8	3:5
Chlorine substituted aldehydes:																
Chloral hydrate	$CCl_3CH(OH)_2$	[1] 98d.	2	50:101	49	32:10	16:86	2:5	0:0	–:–	1:2	2:2	2:2	2:2	2:2	2:–
Ketones:																
Acetone	CH_3COCH_3	56.1	5	58:76	76	27:45	29:29	2:2	0:0	–:–	3:4	5:5	5:5	5:5	5:5	3:2
Camphor	$C_{10}H_{16}O$	209.1	3	18:62	29	7:42	11:19	0:0	0:1	0:0	2:2	2:3	2:3	3:3	3:3	0:2
Camphor in benzene (saturated solution).			3	64:277	23	29:221	19:55	16:1	–:–	–:–	2:3	2:3	3:3	3:3	3:3	0:–
Camphor (1) plus lubricating oil (9).			2	6:29	21	0:19	4:10	0:0	2:0	0:0	0:2	2:2	2:2	2:2	2:2	0:–
Chlorine substituted ketones:																
Chloroacetone	$CH_2ClCOCH_3$	121	6	1:634	.2	0:1	1:15	0:215	0:332	0:71	0:0	0:0	0:2	0:6	0:6	0:6
Chloroacetone (1) plus lubricating oil (9).			2	1:29	3.5	0:19	0:10	1:0	0:0	0:0	0:2	0:2	0:2	0:2	0:2	0:–
Chloroacetone (1) plus lubricating oil (99).			2	10:29	35	1:19	1:10	0:0	0:0	8:0	0:2	1:2	1:2	2:2	2:2	0:–
Chloroacetophenone	$C_6H_5COCH_2Cl$	247	3	0:770	0	0:72	0:276	0:206	0:195	0:21	0:2	0:3	1:3	1:3	2:3	0:3
Chloroacetophenone (1) plus lubricating oil (9).			2	1:29	3.5	0:19	1:10	0:0	0:0	0:0	0:2	0:2	1:2	2:2	2:2	0:–
Chloroacetophenone (1) plus lubricating oil (24).			2	424:600	71	0:1	0:15	104:215	230:298	90:71	0:0	0:0	1:2	2:2	2:2	2:2
Chloroacetophenone (1) plus lubricating oil (49).			2	259:600	43	0:1	0:15	52:215	92:298	115:71	0:0	1:0	2:2	2:2	2:2	2:2
Chloroacetophenone (1) plus lubricating oil (99).			2	1:29	3.5	0:19	0:10	0:0	1:0	0:0	0:2	0:2	–:	2:2	2:2	0:–

[1] Decomposes at 98°.

TABLE 1.—*Results of chemotropic tests with Cochliomyia macellaria*—Continued

Compound	Formula	Boiling point	Total number of treated jars	Total number flies, treated jars over checks	Percentage ratio for entire period	Ratio for flies visiting jars: First day	Second day	Third day	Fourth day	Fifth day	Ratio for infestation: First day	Second day	Third day	Fourth day	Fifth day	Ratio for emergence
Chlorine substituted ketones—Continued.		° *C.*														
Chloroacetophenone (1) plus petrolatum (2).			1	0:455	0	0:64	0:354	0:37	0:0	0:0	0:0	0:1	0:1	1:1	1:1	0:1
Chloroacetophenone (1) plus kaolin (1).			3	2:684	.3	0:65	1:376	1:242	0:1	0:0	0:2	0:3	1:3	2:3	2:3	0:3
Acids:																
Normal-valeric	$CH_3(CH_2)_3CO_2H$	187	2	97:61	159	49:42	48:19	-:-	-:-	-:-	2:2	2:2	2:2	2:2	2:2	2:2
Normal-caproic	$CH_3(CH_2)_4CO_2H$	202	2	21:59	35	0:8	21:51	0:0	0:0	-:-	1:2	1:2	1:2	1:2	1:2	1:-
Normal-caprylic	$CH_3(CH_2)_6CO_2H$	237.5	3	30:61	49	13:42	17:19	-:-	-:-	-:-	3:3	3:3	3:3	3:3	3:3	1:2
Esters:																
Normal-butyl acetate	$CH_3COOC_4H_9$	126.5	1	0:1	0	0:0	0:0	0:0	0:1	0:0	0:1	0:1	0:1	1:1	1:1	0:0
Amyl acetate	$CH_3COOC_5H_{11}$	142.5	6	132:176	75	39:21	91:148	2:7	0:0	-:-	2:4	6:5	6:5	6:5	6:5	1:-
Amyl acetate (1) plus petrolatum (5).			2	0:5	0	0:0	0:3	0:2	0:0	0:0	1:2	1:2	1:2	1:2	1:2	0:0
Amyl butyrate		178.6	2	99:101	98	18:10	73:86	3:5	5:0	-:-	1:2	2:2	2:2	2:2	2:2	1:-
Amyl butyrate (1) plus petrolatum (5).			2	0:5	0	0:0	0:3	0:2	0:0	0:0	1:2	1:2	1:2	1:2	1:2	0:0
Methyl salicylate	$OHC_6H_4COOCH_3$	223.3	7	70:244	29	15:51	28:102	11:79	15:11	1:1	2:5	5:7	6:7	7:7	7:7	1:3
Amyl salicylate		273	2	40:61	66	22:42	18:19	-:-	-:-	-:-	2:2	2:2	2:2	2:2	2:2	2:2
Halogen substituted esters:																
Beta-chloroethyl acetate.	$CH_3COOCH_2CH_2Cl$	145	4	22:617	3.6	0:1	0:15	3:215	17:315	2:71	0:0	0:0	1:2	1:4	1:4	0:4
Beta-chloroethyl acetate (1) plus lubricating oil (9).			2	3:17	18	0:0	1:0	0:0	2:17	0:0	0:0	0:0	0:0	0:2	0:2	0:2
Beta-bromoethyl acetate.	$CH_3COOCH_2CH_2Br$	70^{27}	4	2:617	.3	0:1	0:15	1:215	1:315	0:71	0:0	1:0	1:2	1:4	1:4	0:4
Beta-bromoethyl acetate (1) plus lubricating oil (9).			2	2:17	12	0:0	1:0	0:0	1:17	0:0	0:0	0:0	0:0	0:2	0:2	0:2
Ethers:																
Beta-naphthylethyl ether.	$C_{10}H_7.O.C_2H_5$	282	9	60:1,506	4	4:128	16:738	24:465	9:175	7:0	1:5	1:9	3:9	5:9	7:9	0:6
Beta-naphthylethyl ether (1) plus petrolatum (5).			1	0:1	0	0:0	0:0	0:0	0:1	0:0	0:0	0:1	0:1	1:1	1:1	0:0

Beta - naphthylethyl ether (1) plus lubricating oil (9).			2	2:29	6.9	1:19	0:10	0:0	1:0	0:0	0:2	1:2	2:2	2:2	2:2	0:–
Chlorohydrins:																
Alpha-epichlorohydrin	C_3H_5ClO	117	2	10:29	35	0:19	1:10	2:0	0:0	7:0	0:2	2:2	2:2	2:2	2:2	0:–
Nitro compounds:																
Nitrobenzene	$C_6H_5NO_2$	210.9	16	132:1,378	9.6	40:322	48:507	26:318	13:209	5:22	4:12	8:16	13:16	13:16	13:16	0:5
Nitrobenzene (1) plus mineral oil (5).			1	122:96	127	0:1	0:38	14:53	85:2	23:2	0:0	0:1	1:1	1:1	1:1	–:–
Nitrobenzene (1) plus petrolatum (5).			2	13:551	2.4	0:65	4:392	0:90	4:2	5:2	0:2	0:2	0:2	1:2	2:2	0:1
Nitrobenzene (1) plus kaolin (4).			3	14:623	2.3	0:65	1:417	8:131	4:7	1:3	0:1	0:3	1:3	3:3	3:3	0:1
Nitrocymene	$CH_3C_6H_3NO_2CH(CH_3)_2$.	150[15]	9	625:1,600	39	0:25	3:325	224:654	315:503	83:93	0:4	1:7	4:9	8:9	8:9	3:7
Nitrocymene (1) plus kaolin (4).			1	0:72	0	0:1	0:25	0:41	0:4	0:1	0:0	0:1	0:1	1:1	1:1	1:0
Alpha - nitronaphthalene.	$C_{10}H_7NO_2$	152[15]	1	10:151	6.6	0:0	0:0	6:35	3:114	1:2	0:1	0:1	1:1	1:1	1:1	1:1
Mixed nitro compounds:																
Chloropicrin (1) plus lubricating oil (9).	CCl_3NO_2	112.4	2	0:29	0	0:19	0:10	0:0	0:0	0:0	0:2	0:2	0:2	0:2	0:2	0:–
Chloropicrin (1) plus lubricating oil (24).			2	14:600	2.3	0:1	0:15	2:215	10:298	2:71	0:0	0:0	0:2	0:2	0:2	0:2
Chloropicrin (1) plus lubricating oil (49).			4	140:617	23	0:1	0:15	40:215	81:315	19:71	0:0	0:0	2:2	2:4	2:4	2:4
Chloropicrin (1) plus lubricating oil (99).			4	7:46	15	1:19	1:10	0:0	5:17	0:0	0:2	0:2	0:2	0:4	0:4	0:2
Para-nitroaniline	$O_2NC_6H_4NH_2$	210[20]	4	11:20	55	2:3	6:13	3:4	0:0	0:0	2:3	4:4	4:4	4:4	4:4	1:4
Picric acid	$OHC_6H_2(NO_2)_3$	exp.[2]	3	19:966	2.0	0:36	5:250	1:255	12:352	1:73	0:0	3:1	3:3	3:3	3:3	2:3
Amines:																
Dimethylaniline	$C_6H_5N(CH_3)_2$	193.5	7	338:976	35	6:48	34:372	142:325	122:209	34:22	0:3	2:7	4:7	6:7	6:7	0:3
Dimethylaniline (1) plus mineral oil (4).			1	245:96	255	0:1	24:38	122:53	90:2	9:2	0:0	0:1	1:1	1:1	1:1	–:–
Dimethylaniline (1) plus petrolatum (5).			1	224:96	233	0:1	0:38	10:53	214:2	0:2	0:1	0:1	0:1	1:1	1:1	–:–
Dimethylaniline (1) plus kaolin (4).			1	114:96	119	0:1	0:38	53:53	57:2	4:2	0:0	0:1	1:1	1:1	1:1	–:–
Alpha-naphthylamine	$C_{10}H_7NH_2$	301	1	4:151	2.6	0:0	0:0	3:35	1:114	0:2	0:1	0:1	0:1	1:1	1:1	0:1
Miscellaneous nitrogenous compounds:																
Pyridine	C_5H_5N	115.3	10	68:1,447	4.7	7:146	26:691	3:334	30:254	2:22	2:5	9:10	10:10	10:10	10:10	0:4
Pyridine (1) plus petrolatum (5).			2	0:5	0	0:0	0:3	0:2	0:0	0:0	1:2	1:2	1:2	1:2	2:2	0:0
Nicotine sulphate (40 per cent solution).	$(C_{10}H_{14}N_2)_2H_2SO_4$		2	22:101	22	4:10	12:87	0:4	6:0	–:–	2:2	2:2	2:2	2:2	2:2	2:–

[2] Explosive above 300°.

TABLE 1.—*Results of chemotropic tests with Cochliomyia macellaria*—Continued

Compound	Formula	Boiling point	Total number of treated jars	Total number flies, treated jars over checks	Percentage ratio for entire period	Ratio for flies visiting jars					Ratio for infestation					Ratio for emergence
						First day	Second day	Third day	Fourth day	Fifth day	First day	Second day	Third day	Fourth day	Fifth day	
Sulphur compounds:		°*C.*														
Carbon disulphide	CS_2	46.3	1	115:154	75	43:54	33:53	22:45	11:2	6:0	0:1	1:1	1:1	1:1	1:1	1:1
Ethyl mercaptan	C_2H_5SH	34.7	2	499:229	218	40:1	53:22	370:205	35:1	1:0	2:2	2:2	2:2	2:2	2:2	2:2
Butyl mercaptan	C_4H_9SH	98	3	269:770	35	9:72	25:276	49:206	140:195	46:21	0:1	3:3	3:3	3:3	3:3	0:3
Allyl isothiocyanate	CH_2CHCH_2NCS	150.7	9	223:1,437	16	1:73	137:630	78:375	7:337	0:22	2:5	3:9	8:9	8:9	8:9	0:4
Allyl isothiocyanate (1) plus mineral oil (4).			1	2:96	2.1	0:1	0:38	0:53	0:2	2:2	0:0	1:1	1:1	1:1	1:1	–:–
Allyl isothiocyanate (1) plus petrolatum (2).			4	71:633	11	0:87	7:443	20:98	44:3	0:2	0:2	0:4	0:4	1:4	2:4	–:–
Allyl isothiocyanate (1) plus petrolatum (1) plus pine-tar oil (1).			1	0:72	0	0:1	0:25	0:41	0:4	0:1	0:0	0:1	0:1	0:1	0:1	0:0
Allyl isothiocyanate (1) plus kaolin (3).			4	7:640	1.1	0:69	0:427	4:133	2:8	1:3	0:2	0:4	3:4	3:4	4:4	0:1
Selenium compounds:																
Diethyl diselenide (1) plus lubricating oil (99).	$(C_2H_5)_2Se_2$		2	5:29	17	1:19	3:10	0:0	0:0	1:0	0:2	1:2	2:2	2:2	2:2	0:–
Diethyl diselenide (1) plus lubricating oil (999).			2	0:29	0	0:19	0:10	0:0	0:0	0:0	0:2	2:2	2:2	2:2	2:2	0:–
Ethyl selenide	$(C_2H_5)_2Se$	108	1	50:154	32	6:54	17:53	21:45	3:2	3:0	0:1	1:1	1:1	1:1	1:1	0:1
Inorganic compounds:																
Antimony trichloride	$SbCl_3$		2	56:229	24	0:1	1:22	53:205	2:1	0:0	1:2	2:2	2:2	2:2	2:2	1:2
Arsenic solution (2 per cent dip).			1	111:154	72	47:54	58:53	4:45	2:2	0:0	1:1	1:1	1:1	1:1	1:1	1:1
Bleaching powder plus petrolatum.			1	9:82	11	0:4	4:40	0:31	5:7	–:–	1:1	1:1	1:1	1:1	1:1	1:1
Borax	$Na_2B_4O_7.10H_2O$		2	255:520	49	24:90	145:288	29:84	24:56	33:2	1:1	2:2	2:2	2:2	2:2	0:2
Copper carbonate			3	1:966	.1	0:36	0:250	0:255	0:352	1:73	0:0	2:1	3:3	3:3	3:3	1:3
Copper sulphate	$CuSO_4.5H_2O$		3	102:754	14	0:55	2:69	16:260	65:299	19:71	1:1	2:1	3:3	3:3	3:3	1:3
Kaolin			4	388:1,293	30	47:166	186:954	100:116	55:56	0:1	1:3	2:4	4:4	4:4	4:4	3:3
Lead acetate	$Pb(C_2H_3O_2)_2.3H_2O$		1	57:154	37	19:54	17:53	20:45	0:2	1:0	1:1	1:1	1:1	1:1	1:1	0:1
Potassium sulphide	K_2S		4	360:1,120	32	15:90	9:303	65:300	231:354	40:73	1:0	3:2	3:4	4:4	4:4	2:4

Essential oil and botanical origin [1]	Principal constituents [1]	Total number of treated jars	Total number of flies, treated jars over checks	Percentage ratio for entire period	Ratio for flies visiting jars: First day	Second day	Third day	Fourth day	Fifth day	Ratio for infestation: First day	Second day	Third day	Fourth day	Fifth day	Ratio for emergence
Anise, star, Illicum verum Hooker (Fam. Magnoliaceæ).	Anethol, safrol	11	142:1,456	9.8	1:175	31:664	54:340	43:255	13:22	0:8	3:11	4:11	7:11	7:11	0:4
Anise, star (1) plus mineral oil (4)		1	61:96	64	0:1	0:38	3:53	24:2	34:2	0:1	0:1	1:1	1:1	1:1	–:–
Anise, star (1) plus petrolatum (5)		2	18:113	16	0:5	0:48	9:55	8:3	1:2	0:1	0:2	2:2	2:2	2:2	–:–
Anise, star (1) plus kaolin (3)		2	15:113	13	0:5	1:48	9:55	3:3	2:2	0:1	0:2	1:2	1:2	2:2	–:–
Bergamot, Citrus bergamia W. & A. (Fam. Rutaceæ).	Linalyl acetate, linalol, limonene.	1	22:366	6	1:36	5:234	5:40	8:55	3:1	0:0	1:1	1:1	1:1	1:1	0:1
Cade, Juniperus oxycedrus L. (Fam. Pinaceæ).	Cadinene	11	59:1,207	4.9	0:48	0:113	20:482	30:492	9:72	0:3	4:6	4:8	8:11	11:11	0:6
Cade (1) plus benzene (2)		1	104:65	160	0:19	6:41	45:5	53:0	–:–	1:1	1:1	1:1	1:1	1:1	–:–
Cade (1) plus lubricating oil (9)		2	5:17	29	0:0	3:0	1:0	1:17	0:0	0:0	0:0	0:0	1:2	1:2	0:2
Cade (1) plus mineral oil (4)		1	121:96	126	0:1	0:38	63:53	47:2	11:2	0:0	0:1	1:1	1:1	1:1	–:–
Cade (1) plus petrolatum (5)		1	0:96	0	0:1	0:38	0:53	0:2	0:2	0:0	0:1	0:1	1:1	1:1	–:–
Cade (1) plus petrolatum (2) plus furfural (1) plus borax (1).		1	0:65	0	0:19	0:41	0:5	0:0	–:–	–:1	–:1	–:1	–:1	–:1	–:–
Cade (1) plus kaolin (3)		1	23:96	24	0:0	0:38	23:53	0:2	0:2	0:0	0:1	1:1	1:1	1:1	–:–
Cajuput, Melaleuca leucodendron L. (Fam. Myrtaceæ).	Cineol, terpineol	7	209:852	25	15:283	108:382	38:128	37:58	11:1	2:5	6:7	6:7	6:7	6:7	1:–
Cajuput (1) plus petrolatum (5)		2	0:5	0	0:1	0:3	0:2	0:0	0:0	0:2	0:2	0:2	0:2	2:2	0:1
Camphor, Cinnamomum camphora L. (Fam. Lauraceæ).	Pinene, camphor, cineol, phellandrene, dipentene, safrol, eugenol.	6	66:619	11	42:269	21:154	0:108	2:67	1:21	2:4	3:6	5:6	6:6	6:6	0:1
Camphor (white special)		9	168:1,242	14	5:269	49:427	50:315	54:209	10:22	1:6	3:9	7:9	8:9	8:9	1:3
Camphor (white special) (1) plus mineral oil (4).		1	27:96	28	0:1	4:38	21:53	2:2	0:2	0:0	1:1	1:1	1:1	1:1	–:–
Camphor (white special) (3) plus petrolatum (1).		1	1:96	1.0	0:1	0:38	1:53	0:2	0:2	0:0	0:1	0:1	1:1	1:1	–:–
Camphor (white special) (1) plus kaolin (3).		2	91:168	54	0:2	0:63	27:93	50:7	14:3	0:0	0:2	2:2	2:2	2:2	0:0
Camphor, Japanese		3	189:212	89	4:29	14:94	81:84	90:5	0:0	1:1	2:3	3:3	3:3	3:3	–:–
Camphor, Japanese (3) plus petrolatum (1).		1	147:17	865	0:4	20:10	124:2	2:1	1:0	0:1	0:1	1:1	1:1	1:1	–:–
Camphor, Japanese (1) plus kaolin (3).		1	3:17	18	0:4	1:10	0:2	2:1	–:1	0:1	0:1	1:1	1:1	1:1	–:–
Camphor by-product (camphor sassy-frassy).		18	391:3,152	12	2:414	34:1,130	158:878	169:637	28:93	0:11	6:16	11:18	12:18	14:18	2:10
Camphor by-product (3) plus petrolatum (1)		4	3:1,023	.3	0:132	0:756	0:130	3:3	0:2	0:1	0:4	1:4	2:4	2:4	0:2

[1] The botanical origin and principal constituents of these essential oils are taken mainly from Van Nostrand's Chemical Annual, fifth issue, 1922.

TABLE 1.—*Results of chemotropic tests with Cochliomyia macellaria*—Continued

Essential oil and botanical origin [1]	Principal constituents [1]	Total number of treated jars	Total number of flies, treated jars over checks	Percentage ratio for entire period	Ratio for flies visiting jars					Ratio for infestation					Ratio for emergence
					First day	Second day	Third day	Fourth day	Fifth day	First day	Second day	Third day	Fourth day	Fifth day	
Camphor by-product (1) plus mineral oil (4).		1	4:96	4.2	0:1	0:38	0:53	3:2	1:2	0:0	0:1	1:1	1:1	1:1	-:-
Camphor by-product (1) plus kaolin (3).		5	19:1,095	1.7	0:132	1:782	2:170	16:8	0:3	0:1	0:5	1:5	2:5	2:5	0:2
Camphor by-product (1) plus benzene (2).		1	110:65	169	0:19	20:41	71:5	18:0	1:0	0:1	1:1	1:1	1:1	1:1	-:-
Camphor by-product (1) plus bone meal (3).		1	0:455	0	0:64	0:354	0:37	0:0	0:0	0:0	0:1	0:1	0:1	0:1	0:1
Camphor by-product (1) plus petrolatum (2) plus furfural (1) plus borax (1).		1	0:65	0	0:19	0:41	0:5	0:0	-:-	0:1	0:1	0:1	0:1	0:1	-:-
Cassia, Cinnamomum cassia Blume (Fam. Lauraceæ).	Cinnamic aldehyde	7	127:514	25	0:31	1:142	69:330	55:10	2:1	0:3	2:7	4:7	6:7	6:7	2:2
Cassia, redistilled		1	0:82	0	0:4	0:40	0:31	0:7	-:-	0:0	1:1	1:1	1:1	1:1	0:1
Cassia (3) plus petrolatum (1)		1	0:17	0	0:4	0:10	0:2	0:1	0:0	0:1	0:1	0:1	0:1	1:1	-:-
Cassia (1) plus kaolin (3)		1	0:17	0	0:4	0:10	0:2	0:1	0:0	0:1	0:1	1:1	1:1	1:1	-:-
Cedar leaf, Juniperus virginiana L. (Fam. Pinaceæ).	Limonene, cadinene, borneol, bornyl esters.	2	97:520	19	0:90	51:288	34:84	10:56	2:2	1:1	2:2	2:2	2:2	2:2	0:2
Cedar wood, Juniperus virginiana L. (Fam. Pinaceæ).	Cedrene, cedar camphor	5	148:593	25	27:99	30:347	14:89	58:56	19:2	1:4	4:5	5:5	5:5	5:5	2:2
Cinnamon, Cinnamomum zeylanicum (Fam. Lauraceæ).	Cinnamic aldehyde, eugenol.	12	196:1,969	10	1:602	80:752	30:338	82:254	3:23	0:9	2:12	9:12	9:12	10:12	0.4
Citronella, Andropogon nardus L. (Fam. Gramineæ).	Geraniol	13	150:800	19	23:522	51:249	57:15	19:14	-:-	7:12	10:13	11:13	12:13	12:13	0:2
Citronella, Java	Geraniol, citronellal	2	146:195	75	0:25	5:84	82:82	57:4	2:-	0:0	1:2	2:2	2:2	2:2	-:-
Citronella, Ceylon		3	6:212	2.8	0:29	1:94	1:84	1:5	3:-	0:1	0:3	2:3	3:3	3:3	-:-
Citronella, Ceylon (1) plus mineral oil (4).		1	9:96	9.4	0:1	0:38	2:53	7:2	0:2	0:0	1:1	1:1	1:1	1:1	-:-
Citronella, Ceylon (3) plus petrolatum (1).		2	7:113	6.2	0:5	0:47	0:56	7:3	0:2	0:1	1:2	1:2	2:2	2:2	-:-
Citronella, Ceylon (1) plus kaolin (3).		2	7:113	6.2	0:5	0:47	4:56	3:3	0:2	0:1	0:1	0:2	2:2	2:2	-:-
Citronella, Ceylon (1) plus benzene (1).		1	91:65	140	0:19	0:41	30:5	60:0	1:0	1:1	1:1	1:1	1:1	1.1	-:-
Citronella, Ceylon (1) plus petrolatum (2) plus furfural (1) plus borax (1).		1	0:65	0	0:19	0:41	0:5	0:0	-:-	0:1	0:1	0:1	0:1	0:1	-:-

Clove, Eugenia aromatica L. (Fam. Myrtaceæ).	Eugenol, caryophyllene	10	105:1,107	9.5	0:79	28:474	35:322	30:210	12:22	0:7	2:10	6:10	7:10	9:10	1:3
Clove (1) plus mineral oil (4)		1	19:96	20	0:1	0:38	1:53	18:2	0:2	0:0	0:1	1:1	1:1	1:1	-:-
Clove (3) plus petrolatum (1)		2	1:113	.9	0:5	0:47	1:56	0:3	0:2	0:1	0:2	1:2	2:2	2:2	-:-
Clove (1) plus kaolin (3)		2	3:113	2.7	0:5	0:47	2:56	1:3	0:2	0:1	0:2	2:2	2:2	2:2	-:-
Clove (1) plus benzene (2)		1	77:65	118	0:19	20:41	50:5	7:0	-:-	-:1	-:1	-:1	-:1	-:1	-:-
Clove (1) plus petrolatum (2) plus citronella (1).		1	3:65	4.6	0:19	0:41	0:5	2:0	1:-	-:1	-:1	-:1	-:1	-:1	-:-
Clove bud		5	54:893	6.0	12:239	30:277	11:162	0:194	1:21	0:4	3:5	3:5	4:5	5:5	0:2
Clove bud (3) plus petrolatum (1)		1	0:455	0	0:64	0:354	0:37	0:0	0:0	0:0	0:1	0:1	0:1	1:1	0:1
Clove bud (1) plus kaolin (3)		1	1:455	.2	0:64	1:354	0:37	0:0	0:0	0:0	0:1	0:1	0:1	0:1	0:1
Copaiba, Copaiba langadorffii. (Fam. Leguminosæ).	Sesquiterpenes	3	126:209	60	0:26	5:92	33:87	65:4	23:-	0:1	2:3	3:3	3:3	3:3	-:-
Coriander, Coriandrum sativum (Fam. Umbelliferæ).	Linalol, pinene	7	67:1,331	5.0	0:133	17:595	22:327	21:254	7:22	0:3	2:7	5:7	6:7	6:7	1:4
Coriander (1) plus mineral oil (4)		1	80:96	83	0:1	9:38	48:53	23:2	0:2	0:0	1:1	1:1	1:1	1:1	-:-
Coriander (1) plus kaolin (3)		1	106:96	110	0:1	0:38	10:53	89:2	7:2	0:0	0:1	1:1	1:1	1:1	-:-
Cumin, Cuminum cyminum (Fam. Umbelliferæ).	Cymene, cumic aldehyde	10	179:899	20	19:506	39:281	111:95	10:17	-:-	2:9	5:10	8:10	8:10	8:10	-:-
Eucalyptus, Eucalyptus spp. Fam. Myrtaceæ).	Cineol, phellandrene, etc.	4	148,349	42	1:30	63:150	76:153	7:15	1:1	1:2	3:4	4:4	4:4	4:4	1:1
Eucalyptus (1) plus kaolin (3)		1	7:72	9.7	0:1	0:25	0:41	0:4	7:1	0:0	0:1	0:1	0:1	1:1	1:0
Fennel, Foeniculum capillaceum (Fam. Umbelliferæ).	Anethol, fenchone	16	152:1,345	11	15:532	57:426	57:370	23:16	0:1	1:13	10:16	12:16	13:16	14:16	2:3
Fennel (1) plus mineral oil (4)		1	58:96	60	0:1	4:38	36:53	5:2	13:2	0:0	0:1	1:1	1:1	1:1	-:-
Fennel (3) plus petrolatum (1)		4	14:118	12	0:5	0:50	11:58	2:3	1:2	0.3	0:4	2:4	2:4	4:4	0:0
Fennel (1) plus kaolin (3)		2	34:113	30	0:5	6:47	20:56	6:3	2:2	0:1	1:2	2:2	2:2	2:2	-:-
Geranium, rose, Pelargonium spp. (Fam. Geraniaceæ).	Geraniol, citronellol, and their esters.	5	91:1,136	7.6	0:108	16:510	56:245	15:251	4:22	0:2	1:5	2:5	4:5	4:5	1:4
Hemlock, Abies canadensis Michx. and Picea alba and P. nigra L. (Fam. Pinaceæ).		2	118:195	61	0:25	7:84	73:82	31:4	7:0	1:1	2:2	2:2	2:2	2:2	-:-
Juniper wood (artificial)	Spirits of gum turpentine	4	122:610	20	49:467	64:142	9:1	-:-	-:-	3:4	4:4	4:4	4:4	4:4	-:-
Lavender, garden (artificial)	Spirits of gum turpentine	1	79:366	22	0:36	59:234	8:40	10:55	2:1	0:0	0:1	1:1	1:1	1:1	0:-
Lavender, spike, Lavandula spica D. C. (Fam. Labiatae).	Pinene, camphene, cineol, camphor, borneol, linalol	2	144:380	38	1:37	116:242	12:45	9:55	6:1	1:0	2:2	2:2	2:2	2:2	1-1
Lemon, Citrus medica var. limonum Hooker (Fam. Rutaceæ).	d-limonene, citral	3	67:277	24	30:221	19:55	18:1	-:-	-:-	2:3	2:3	2:3	2:3	2:3	-:-
Lemongrass, Andropogon citratus Stapf. (Fam. Gramineæ).	Citral, geraniol, methyl heptenone.	3	154:277	56	5:221	134:55	15:1	-:-	-:-	2:3	3:3	3:3	3:3	3:3	-:-
Nutmeg, Myristica fragrans Houttuyn (Fam. Myristicaceæ).	Myristicin, pinene	2	15:154	9.7	0:5	2:65	2:72	6:11	5:1	0:1	1:2	1:2	2:2	2:2	0:1
Origanum, Origanum hirtum (Fam. Labiatæ).	Carvacrol, cymene	6	111:177	63	41:55	64:115	3:7	3:0	-:-	4:5	6:6	6:6	6:6	6:6	1:2
Origanum (3) plus petrolatum (1)		2	0:5	0	0:0	0:3	0:2	0:0	0:0	0:2	0:2	1:2	1:2	1:2	0:0
Pennyroyal, American, Hedeoma pulegioides L. (Fam. Labiatæ).	Pulegone, hedeomol	11	206:2,209	9.3	122:1,971	61:230	22.8	1:0	-:-	5:10	5:11	5:11	5:11	5:11	0:2
Peppermint, Mentha piperita L. (Fam. Labiatæ).	Menthol, esters of menthol, menthone, pinene, cineol, phellandrene, limonene, cadinene.	7	363:689	53	135:479	153:188	72.9	3:13	-:-	4:7	5:7	6:7	6:7	6:7	-:-

[1] The botanical origin and principal constituents of these essential oils are taken mainly from Van Nostrand's Chemical Annual, fifth issue, 1922.

TABLE 1.—*Results of chemotropic tests with Cochliomyia macellaria*—Continued

Essential oil and botanical origin [1]	Principal constituents [1]	Total number of treated jars	Total number of flies, treated jars over checks	Percentage ratio for entire period	Ratio for flies visiting jars: First day	Second day	Third day	Fourth day	Fifth day	Ratio for infestation: First day	Second day	Third day	Fourth day	Fifth day	Ratio for emergence
Rosemary, Rosmarinus officinalis L. (Fam. Labiatæ).	Pinene, camphene, cineol, camphor, borneol, bornyl acetate.	2	104:195	53	0:25	15:84	56:82	33:4	-:-	0:1	2:2	2:2	2:2	2:2	-:-
Sandalwood, Santalum album L. (Fam. Santalaceæ).	Santal alcohols, santalol, esters of santal alcohols.	6	233:1,331	13	15:133	74:595	90:327	49:254	5:22	0:3	2:6	5:6	6:6	6:6	1:4
Sassafras, Sassafras variifolium O. Kuntze (Fam. Lauraceæ).	Safrol, eugenol, camphor, pinene, phellandrene.	8	144:1,312	11	8:487	26:397	42:208	13:198	55:22	1:6	5:8	5:8	5:8	5:8	0:2
Sassafras (1) plus mineral oil (4)		1	44:96	46	0:1	4:38	33:53	4:2	3:2	0:0	0:1	1:1	1:1	1:1	-:-
Sassafras (3) plus petrolatum (1)		3	9:568	1.6	0:68	2:402	2:93	5:3	0:2	0:1	1:3	2:3	3:3	3:3	0:1
Sassafras (1) plus kaolin (3)		2	93:113	82	0:5	1:47	5:56	71:3	16:2	0:1	2:2	2:2	2:2	2:2	-:-
Sassafras, artificial	Safrol	5	115:828	14	0:47	3:317	40:245	62:199	10:20	0:2	0:4	1:4	2:4	3:4	0:2
Sassafras, artificial (1) plus kaolin (3).		1	1:455	.2	0:64	1:354	0:37	0:0	0:0	0:0	0:1	0:1	1:1	1:1	0:1
Spearmint, Mentha viridis L. (Fam. Labiatæ.)	Carvone, limonene, pinene	9	119:1,561	7.6	0:134	8:617	52:533	53:255	6:22	0:5	5:9	8:9	9:9	9:9	1:6
Tansy, Tanacetum vulgare L. (Fam. Compositæ.)	Thujone, camphor, borneol	5	33:161	20	8:18	25:138	0:5	0:0	-:-	2:4	5:5	5:5	5:5	5:5	0:0
Thyme, Thymus vulgaris L. (Fam. Labiatæ.)	Thymol, carvacrol, cymene, linalol, borneol.	10	394:1,492	26	5:151	175:733	89:331	100:254	25:23	1:6	6:10	8:10	8:10	9:10	0:4
Wormseed, American, Chenopodium neuopodium (anthelminticum) L. (Fam. Chenopodiaceæ.)	Ascaridol	11	212:832	25	51:527	101:299	59:6	1:0	-:-	2:10	8:11	9:11	9:11	9:11	1:2

Material	Total number of treated jars	Total number of flies, treated jars over checks	Percentage ratio for entire period	Ratio for flies visiting jars: First day	Second day	Third day	Fourth day	Fifth day	Ratio for infestation: First day	Second day	Third day	Fourth day	Fifth day	Ratio for emergence
Fatty oils:														
Almond	3	88:209	42	21:26	58:92	4:87	5:4	-:-	1:2	2:3	3:3	3:3	3:3	-:-
Fish	8	260:771	34	170:485	89:280	1:6	0:0	-:-	4:8	6:8	7:8	7:8	7:8	-:-
Peach kernel	2	30:195	15	0:25	5:84	23:82	2:4	-:-	0:1	1:2	2:2	2:2	2:2	-:-

Miscellaneous vegetable products:														
Angelica root: Angelica archangelica L. (Fam. Umbelliferæ). Contains angelic, valeric, oxymyristic and oxypentadecylic acids; phellandrene	1	78:366	21	7:36	54:235	2:40	15:54	0:1	0:0	1:1	1:1	1:1	1:1	0:1
Asafœtida (glycerated) in alcohol: A gum resin obtained from the root of Ferula fœtida Regel (Fam. Umbelliferæ)	2	25:29	86	4:19	6:10	15:0	0:0	0:0	1:2	2:2	2:2	2:2	2:2	–:–
Canada snake root: Asarum canadense L. (Fam. Aristolochiaceae). Contains eugenol, methyl ether, pinene, geraniol, etc	1	38:82	46	1:4	8:40	22:31	7:7	–:–	0:0	1:1	1:1	1:1	1:1	1:1
Cinnamon powder: The inner bark of Cinnamomum zeylanicum Breyne (Fam. Lauraceæ). Contains cinnamic aldehyde and eugenol	4	217:357	61	0:1	3:28	103:236	108:92	3:0	0:2	2:4	4:4	4:4	4:4	2:4
Clove powder, flower buds of Eugenia aromatica (Linné) O. Kuntze (Fam. Myrtaceæ). Contains eugenol	12	71:1,502	4.7	15:269	4:411	10:420	41:379	1:23	0:6	2:12	3:12	7:12	9:12	0:4
Clove powder (1) plus petrolatum (2)	2	0:456	0	0:64	0:354	0:37	0:1	0:0	0:0	0:2	1:2	2:2	2:2	0:1
Clove powder (1) plus kaolin (4)	1	4:455	.9	0:64	2:354	0:37	0:0	2:0	0:0	0:1	0:1	0:1	1:1	0:1
Deer-tongue leaves	1	16:366	4.4	0:36	3:234	3:40	10:55	0:1	1:0	1:1	1:1	1:1	1:1	1:1
Derris powder, Derris elliptica (Wall.) Benth. and Derris uliginosa Benth. (Fam. Fabaceæ)	5	30:634	4.7	0:0	0:28	0:38	29:535	1:33	0:1	0:5	2:5	4:5	5:5	0:4
Lupulin, the glandular trichomes separated from the fruit of hops, Humulus lupulus Linné (Fam. Moraceæ)	1	80:366	22	0:36	4:234	0:40	16:55	60:1	0:0	1:1	1:1	1:1	1:1	1:1
Pennyroyal leaves, Hedeoma pulegioides (Linné) Persoon (Fam. Labiatæ)	1	336:366	92	12:36	238:234	29:40	51:55	6:1	0:0	1:1	1:1	1:1	1:1	1:1
Peppermint leaves, Mentha piperita Linné (Fam. Labiatæ)	1	215:366	59	24:36	163:234	18:40	10:55	0:1	0:0	1:1	1:1	1:1	1:1	1:1
Pyrethrum powder, flowers of Chrysanthemum (Pyrethrum) cinerariaefolium (Trev.) Bocc. (Fam. Compositæ)	6	50:862	5.8	0:1	0:50	31:243	16:535	3:33	0:3	0:6	3:6	5:6	6:6	0:6
Pyrethrum (kerosene extract) 2 pounds per gallon	2	23:17	135	0:0	0:0	0:0	23:17	0:0	0:0	0:0	0:0	1:2	1:2	0:2
Pyrethrum (alcohol extract) 2 pounds per gallon	2	250:600	42	1:1	17:15	84:215	118:298	30:71	0:0	0:0	0:2	0:2	0:2	0:2
Sassafras bark, bark of the root of Sassafras variifolium (Salisbury) O. Kuntze (Fam. Lauraceæ)	1	40:366	11	0:36	4:234	6:40	30:55	0:1	0:0	1:1	1:1	1:1	1:1	1:1
Valerian root, Valeriana officinalis Linné (Fam. Valerianaceæ)	1	17:82	21	0:4	9:40	6:31	2:7	–:–	0:0	1:1	1:1	1:1	1:1	1:1
Valerian root (1) plus petrolatum (1)	1	38:82	46	1:4	24:40	11:31	2:7	–:–	0:0	1:1	1:1	1:1	1:1	1:1
Valerian root (1) plus kaolin (1)	1	29:82	35	0:4	8:40	12:31	9:7	–:–	0:0	1:1	1:1	1:1	1:1	1:1
Wormseed (American), fruit of Chenopodium neuopodium (anthelminticum) Linné (Fam. Chenopodiaceæ)	2	17:154	11	0:5	2:65	14:72	1:11	0:1	0:0	1:2	1:2	2:2	2:2	1:1
Pine products:														
Pinap	4	0:160	0	0:0	0:35	0:33	0:91	0:1	0:1	2:4	4:4	4:4	4:4	0:2
Pinap (1) plus pine-tar oil (1)	2	19:198	9.6	0:0	0:1	2:154	16:43	1:0	0:2	2:2	2:2	2:2	2:2	0:0
Pine oil (Acme Co.)	2	5:475	.99	0:0	0:22	0:7	5:443	0:3	0:1	0:2	1:2	2:2	2:2	0:2
Pine oil, crude	2	14:616	2.3	0:18	11:222	1:161	2:194	0:21	0:1	0:2	1:2	2:2	2:2	1:2
Pine oil, refined	8	1:428	.23	0:19	0:46	0:187	0:174	1:2	0:5	3:8	3:8	5:8	6:8	0:2
Pine oil, pure steam distilled	8	42:647	6.5	0:20	3:25	3:215	29:316	7:71	0:2	1:4	3:6	4:8	4:8	1:4
Pine oil, pure amber steam distilled	3	51:617	8.3	0:18	38:222	8:161	3:195	2:21	0:1	0:3	0:3	1:3	2:3	0:2
Pine oil, pure amber steam distilled (1) plus petrolatum (2)	1	0:1	0	0:0	0:0	0:0	0:1	0:0	0:0	0:1	0:1	0:1	0:1	0:0
Pine oil No. 4	10	2:932	.21	0:19	0:68	0:194	0:617	2:34	0:6	3:10	6:10	7:10	8:10	0:4
Pine oil No. 4 (1) plus refined tar oil (1)	2	4:238	1.7	0:0	0:1	2:154	2:83	0:0	0:2	1:2	2:2	2:2	2:2	0:0
Pine oil No. 4 (1) plus pine-tar oil (1)	2	1:238	.42	0:0	0:1	1:154	0:83	0:0	0:2	1:2	2:2	2:2	2:2	0:0
Pine tar	16	93:2,373	3.9	0:262	17:1,303	21:556	34:228	21:24	0:9	3:16	8:16	10:16	11:16	0:6
Pine tar acid	2	12:505	2.4	0:0	0:22	0:7	12:443	0:33	1:1	2:2	2:2	2:2	2:2	1:2
Pine tar, heavy	4	0:160	0	0:0	0:35	0:33	0:91	0:1	0:1	2:4	4:4	4:4	4:4	0:2
Pine tar, heavy (1) plus crude turpentine (1)	2	0:32	0	0:0	0:29	0:2	0:0	0:1	0:1	1:2	1:2	2:2	2:2	0:0

[1] The botanical origin and principal constituents of these essential oils are taken mainly from Van Nostrands' Chemical Annual, fifth issue, 1922.

TABLE 1.—*Results of chemotropic tests with Cochliomyia macellaria*—Continued

Material	Total number of treated jars	Total number of flies, treated jars over checks	Percentage ratio for entire period	Ratio for flies visiting jars					Ratio for infestation					Ratio for emergence
				First day	Second day	Third day	Fourth day	Fifth day	First day	Second day	Third day	Fourth day	Fifth day	
Pine products—Continued.														
Pine tar, heavy (1) plus pinap (1)	2	0:32	0	0:0	0:29	0:2	0:0	0:1	0:1	2:2	2:2	2:2	2:2	0:0
Pine tar (1) plus borax (1)	3	11:688	1.6	0:19	9:247	2:202	0:198	0:22	0:1	0:3	2:3	2:3	2:3	0:2
Pine tar (1) plus borax (1) plus kaolin (2)	1	3:455	.66	0:64	2:354	1:37	0:0	0:0	0:0	1:1	1:1	1:1	1:1	0:1
Pine tar (1) plus borax (1) plus petrolatum (2)	1	7:455	1.5	0:64	5:354	2:37	0:0	0:0	0:0	0:1	1:1	1:1	1:1	1:1
Pine tar, medium	4	0:160	0	0:0	0:35	0:33	0:91	0:1	0:1	1:4	3:4	4:4	4:4	1:2
Pine tar, thin	4	0:160	0	0:0	0:35	0:33	0:91	0:1	0:1	2:4	2:4	4:4	4:4	0:2
Turpentine, crude	7	21:747	2.8	0:4	6:97	8:71	7:541	0:34	1:3	6:7	7:7	7:7	7:7	1:5
Turpentine, gum	2	3:5	60	3:0	0:3	0:2	0:0	0:0	1:2	1:2	1:2	1:2	1:2	0:0
Rosin residue (1) plus pine oil (1)	2	3:505	.6	0:0	0:22	1:7	2:443	0:33	0:1	0:2	1:2	2:2	2:2	0:2
Rosin spirits, crude	1	61:72	85	0:1	0:25	0:41	0:4	61:1	0:0	0:1	1:1	1:1	1:1	0:0
Rosin spirits, crude (1) plus kaolin (3)	1	9:82	11	0:4	4:40	5:31	0:7	-:-	0:1	1:1	1:1	1:1	1:1	0:1
Pine-oil foots (1) plus furfural (1)	2	9:505	1.8	0:0	0:22	2:7	6:443	1:33	2:1	2:2	2:2	2:2	2:2	0:2
Wood naphtha	4	46:116	40	2:13	44:97	0:6	0:0	-:-	1:4	4:4	4:4	4:4	4:4	0:0
Wood naphtha (1) plus kaolin (3)	1	19:82	23	0:4	1:40	9:31	9:7	-:-	0:1	0:1	1:1	1:1	1:1	1:1
Wood naphtha (1) plus petrolatum (5)	2	0:5	0	0:0	0:3	0:2	0:0	0:0	0:2	0:2	0:2	0:2	0:2	0:0
Wood-tar oil	6	9:625	1.4	4:470	3:152	2:3	-:-	-:-	0:5	4:6	4:6	4:6	4:6	0:0
Wood creosote	7	35:465	7.5	6:92	18:234	7:133	4:5	0:1	0:5	4:7	5:7	6:7	6:7	0:1
Wood creosote (1) plus kaolin (3)	1	13:82	16	0:4	0:40	10:31	3:7	-:-	0:1	1:1	1:1	1:1	1:1	1:1
Wood-creosote oil	2	0:505	0	0:0	0:22	0:7	0:443	0:33	0:0	0:2	2:2	2:2	2:2	0:2
Wood creosote (1) plus petrolatum (5)	2	0:5	0	0:0	0:3	0:2	0:0	0:0	0:2	0:2	0:2	0:2	1:2	0:0
Wood creosote (1) plus glycerin (1)	2	88:229	38	0:1	0:22	58:205	29:1	1:0	0:2	1.2	2:2	2:2	2:2	1:2
Pine-tar oil, refined	9	1:999	.1	0:18	0:244	0:347	1:369	0:21	0:4	2:9	7:9	8:9	9:9	0:5
Pine-tar oil, refined (1) plus petrolatum (5)	2	0:456	0	0:64	0:354	0:37	0:1	0:0	0:0	0:2	0:2	0:2	0:2	0:1
Pine-tar oil, refined (1) plus kaolin (3)	1	0:455	0	0:64	0:354	0:37	0:0	0:0	0:0	0:1	0:1	0:1	0:1	0:1
Pine-tar oil	12	35:798	4.4	0:53	4:208	8:346	19:190	4:1	1:6	7:12	10:12	12:12	12:12	0:3
Pine-tar oil, commercial	10	0:491	0	0:19	0:45	0:102	0:319	0:6	0:5	2:10	7:10	8:10	8:10	1:6
Pine-tar oil, crude	2	0:10	0	0:0	0:0	0:0	0:10	0:0	0:0	0:2	0:2	0:2	1:2	0:0
Pine-tar oil, crude (1) plus petrolatum (5)	3	0:6	0	0:0	0:3	0:2	0:1	0:0	0:2	0:3	0:3	0:3	1:3	0:0
Commercial pine-tar oil mixtures:														
Pine-tar oil (3) plus chloroacetophenone (1)	2	0:0	------	0:0	0:0	0:0	0:0	0:0	0:0	0:2	1:2	2:2	2:2	0:2
Pine-tar oil (3) plus furfural (1) plus star-anise oil (1)	2	0:302	0	0:0	0:0	0:69	0:228	0:5	0:2	0:2	0:2	0:2	0:2	0:2
Pine-tar oil (3) plus furfural (1) plus camphor sassy (1)	2	0:302	0	0:0	0:0	0:69	0:228	0:5	0:2	0:2	0:2	0:2	0:2	0:2
Pine-tar oil (3) plus furfural (1) plus a creosote dip (1)	2	0:302	0	0:0	0:0	0:69	0. 228	0:5	0:2	0:2	0:2	0:2	1:2	0:2
Pine-tar oil (1) plus furfural (1)	2	0:238	0	0:0	0:1	0:154	0:83	0:0	0:2	0:2	2:2	2:2	2:2	0:0
Pine-tar oil (3) plus furfural (1)	4	3:302	1.0	0:0	0:0	0:69	2:228	1:5	0:2	0:4	2:4	3:4	3:4	1:4
Pine-tar oil (4) plus furfural (1)	2	0:1	0	0:0	0:0	0:0	0:1	0:0	0:0	0:2	0:2	1:2	1:2	0:0
Pine-tar oil (10) plus furfural (1)	2	0:302	0	0:0	0:0	0:69	0:228	0:5	0:2	0:2	0:2	1:2	1:2	0:2

Pine-tar oil (20) plus furfural (1)	2	0:302	0	0:0	0:0	0:69	0:228	0:5	0:2	0:2	0:2	0:2	0:2	0:2
Pine-tar oil (3) plus furfural (1) plus fennel oil (1)	2	0:302	0	0:0	0:0	0:69	0:228	0:5	0:2	0:2	0:2	0:2	0:2	0:2
Pine-tar oil (3) plus furfural (1) plus safrol (1)	2	0:302	0	0:0	0:0	0:69	0:228	0:5	0:2	0:2	0:2	0:2	0:2	0:2
Pine-tar oil (3) plus furfural (1) plus artificial sassafras oil (1)	2	0:302	0	0:0	0:0	0:69	0:228	0:5	0:2	0:2	0:2	0:2	0:2	0:2
Pine-tar oil (3) plus safrol (1) plus camphor sassy (1)	2	0:302	0	0:0	0:0	0:69	0:228	0:5	0:2	0:2	0:2	1:2	1:2	0:2
Pine-tar oil (3) plus safrol (1) plus artificial sassafras oil (1)	2	2:302	.7	0:0	1:0	0:69	0:228	1:5	0:2	0:2	1:2	1:2	1:2	0:2
Pine-tar oil (3) plus safrol (1) plus anise oil (1)	2	1:302	.3	0:0	0:0	0:69	0:228	1:5	0:2	0:2	0:2	0:2	1:2	0:2
Pine-tar oil (3) plus safrol (1) plus fennel oil (1)	2	0:302	0	0:0	0:0	0:69	0:228	0:5	0:2	0:2	0:2	0:2	0:2	0:2
Pine-tar oil (3) plus beta-naphthylethyl ether (1)	2	0:0	-------	0:0	0:0	0:0	0:0	0:0	0:0	1:2	2:2	2:2	2:2	0:2
Pine-tar oil (3) plus camphor by-product oil (1)	2	0:0	-------	0:0	0:0	0:0	0:0	0:0	0:2	0:2	1:2	2:2	2:2	0:2
Pine-tar oil (3) plus citronella oil (1)	2	0:0	-------	0:0	0:0	0:0	0:0	0:0	0:0	0:2	2:2	2:2	2:2	0:2
Pine-tar oil (3) plus clove-bud oil (1)	2	0:0	-------	0:0	0:0	0:0	0:0	0:0	0:0	0:2	2:2	2:2	2:2	0:2
Pine-tar oil (3) plus cinnamic aldehyde (1)	2	0:0	-------	0:0	0:0	0:0	0:0	0:0	0:0	1:2	2:2	2:2	2:2	0:2
Pine-tar oil (3) plus fennel oil (1)	2	0:0	-------	0:0	0:0	0:0	0:0	0:0	0:0	0:2	0:2	2:2	2:2	0:2
Pine-tar oil (3) plus sassafras oil (1)	2	0:0	-------	0:0	0:0	0:0	0:0	0:0	0:0	0:2	2:2	2:2	2:2	0:2
Pine-tar oil (3) plus nitrocymene (1)	2	0:0	-------	0:0	0:0	0:0	0:0	0:0	0:0	0:2	1:2	2:2	2:2	0:2
Pine-tar oil (1) plus safrol (1)	2	4:238	1.7	0:0	0:1	1:154	3:83	0:0	0:2	0:2	2:2	2:2	2:2	0:0
Pine-tar oil (3) plus safrol (1)	4	0:302	0	0:0	0:0	0:69	0:228	0:5	0:2	0:4	2:4	2:4	2:4	0:4
Pine-tar oil (10) plus safrol (1)	2	0:302	0	0:0	0:0	0:69	0:228	0:5	0:2	0:2	1:2	1:2	2:2	0:2
Pine-tar oil (20) plus safrol (1)	2	0:302	0	0:0	0:0	0:69	0:228	0:5	0:2	0:2	0:2	0:2	0:2	0:2
Pine-tar oil (3) plus salicylic aldehyde (1)	4	0:238	0	0:0	0:1	0:154	0:83	0:0	0:2	0:4	1:4	2:4	3:4	0:2
Pine-tar oil (3) plus safrol (1) plus salicylic aldehyde (1)	2	0:238	0	0:0	0:1	0:154	0:83	0:0	0:2	0:2	0:2	0:2	0:2	0:0
Pine-tar oil (3) plus wood creosote U. S. P. (1)	2	1:0	-------	0:0	0:0	0:0	0:0	1:0	0:0	0:2	2:2	2:2	2:2	0:2
Furfural mixtures:														
Furfural (1) plus petroleum (1)	2	16:505	3.2	0:0	0:22	0:7	2:443	14:33	0:1	2:2	2:2	2:2	2:2	0:2
Furfural (2) plus pine-tar oil (3) plus zinc stearate (2)	2	0:505	0	0:0	0:22	0:7	0:443	0:33	0:1	0:2	2:2	2:2	2:2	0:2
Furfural (1) plus petrolatum (2) plus zinc oxide (1)	2	1:505	.2	0:0	0:22	0:7	0:443	1:33	0:1	2:2	2:2	2:2	2:2	1:2
Furfural (1) plus castor oil (1) plus rosin (1)	2	1:505	.2	0:0	0:22	1:7	0:443	0:33	1:1	2:2	2:2	2:2	2:2	0:2
Furfural (1) plus petrolatum (1) plus grafting wax (2)	2	11:505	2.2	0:0	0:22	1:7	10:443	0:33	1:1	2:2	2:2	2:2	2:2	0:2
Furfural (1) plus castor oil (1) plus grafting wax (2)	2	0:505	0	0:0	0:22	0:7	0:443	0:33	0:1	1:2	2:2	2:2	2:2	0:2
Furfural (1) plus gum galbanum (1)	2	6:505	1.2	0:0	0:22	0:7	6:443	0:33	0:1	2:2	2:2	2:2	2:2	0:2
Coal-tar creosotes:														
Coal-tar creosote	3	4:982	.4	0:54	3:457	0:201	1:248	0:22	0:1	0:3	0:3	0:3	0:3	0:3
Coal-tar creosote (1) plus petrolatum (5)	2	1:456	.2	0:64	1:354	0:37	0:1	0:0	0:0	1:2	1:2	1:2	1:2	0:1
Coal-tar creosote (1) plus kaolin (3)	1	0:455	0	0:64	0:354	0:37	0:0	0:0	0:0	0:1	0:1	0:1	0:1	0:1
Miscellaneous:														
Bone meal	1	168:455	37	10:64	153:354	5:37	0:0	0:0	1:0	1:1	1:1	1:1	1:1	1:1

DISCUSSION OF RESULTS

COMPOUNDS

HYDROCARBONS

Petrolatum is the only hydrocarbon exhibiting a decided repellent action, and this persists during the first day of exposure only. However, since 1,636 flies out of the total number of 1,659 visited one of the six jars, and 1,454 of these appeared on the second day, it is possible that the meat in this jar was incompletely covered with the petrolatum, and that additional tests will show petrolatum to have a repellent action persisting during the entire time of exposure. The tests with lubricating oil, toluene mixed with petrolatum, naphthalene, and anthracene were made at times when the number of screw-worm flies present was insufficient to yield an accurate result.

The hydrocarbons are not effective in preventing infestation. The best from this standpoint is toluene, since only two out of six jars treated with this compound were infested.

BROMIDES

Para-xylyl bromide is one of the strongest repellents against screw-worm flies discovered in the course of this investigation, its coefficient of attractiveness being only 0.16. Its repellent action persists during five days of exposure. Although it seemingly loses its repellent action when mixed with lubricating oil, these tests were made when too few flies were available for drawing a conclusion. Alpha-bromonaphthalene also is a good repellent against Cochliomyia flies, and its action persists for at least three days. The tests with bromoform mixed with kaolin, ethylene bromide, and benzyl bromide were made at times when the number of screw-worm flies present was insufficient to yield an accurate result.

Para-xylyl bromide is very effective in preventing infestation. None of the meat treated with the pure compound was infested with any species of fly, and none of the meat treated with para-xylyl bromide in lubricating oil, either in 1 per cent or 10 per cent solution, hatched out Cochliomyia flies. Alpha-bromonaphthalene prevented infestation of meat till the third day of exposure, and no Cochliomyia emerged from any of the jars treated with it.

CHLORIDES

A single test with chloroform indicates that it is attractive to screw-worm flies. Pinene hydrochloride and benzyl chloride are the most strongly repellent of the chlorides tested and are effective over the entire period of five days' exposure. Hexachloroethane is effective over a period of three days. Para-xylyl chloride is very much less effective than the corresponding bromide. The tests with benzyl chloride mixed with lubricating oil, para-xylyl chloride mixed with lubricating oil, and chlorinated naphthalene are inconclusive, owing to the absence of an adequate number of flies at the times the tests were carried out.

Benzyl chloride and benzyl chloride in lubricating oil were effective in preventing infestation by any species of fly, and para-xylyl chloride

effectively prevented infestation by Cochliomyia even when mixed with lubricating oil in 10 per cent solution.

IODIDES

Iodoform is a very good repellent, either alone or mixed with kaolin or with petrolatum. It is not effective in preventing infestation, but no Cochliomyia flies emerged from iodoform-treated meat.

ALCOHOLS

Denatured alcohol appears to be slightly attractive to screw-worm flies, and dextro-borneol, when dissolved in alcohol, becomes more attractive to them. Alpha-terpineol and dextro-borneol are the only compounds in this group exhibiting more than a slight repellent action. The tests with fusel oil, glycerin, and linalool are inconclusive, owing to an insufficient number of flies.

Nearly all of the jars treated with alcohols were infested, but in the case of linalool and menthol this was by species other than Cochliomyia.

PHENOLS

Guaiacol is the most effective compound in this group as a repellent for screw-worm flies. Its action persists over five days of exposure. Safrol is effective for the first and second days of exposure, but after that it loses its strength. Tests with ortho-cresol and with thymol plus pine oil are inconclusive because of an insufficient number of flies.

The phenols are surprisingly poor in preventing infestation. While the two jars of meat treated with guaiacol were infested, there was no emergence of Cochliomyia from them; neither did any Cochliomyia emerge from thymol-treated meat.

ALDEHYDES

Benzaldehyde and furfural are the most effective repellents in this group. Cinnamic aldehyde is a good repellent for two days, and crotonaldehyde and salicylic aldehyde are effective over a period of three days' exposure. The test with formaldehyde mixed with petrolatum is inconclusive, as there were almost no flies at that time.

None of the aldehydes are effective in preventing infestation. No Cochliomyia emerged from meat treated with formaldehyde, crotonaldehyde, citronellal, or furfural, but the emergence data on these compounds are meager.

CHLORINE SUBSTITUTED ALDEHYDES

Chloral hydrate is of no value in repelling Cochliomyia flies, neither does it prevent infestation.

KETONES

All of the materials in this group appear valueless both as repellents against screw-worm flies, and in preventing infestation.

CHLORINE SUBSTITUTED KETONES

As a group, this is the most effective class of compounds tested, both in repellent action and in preventing infestation. The tests with chloroacetone in lubricating oil (1 per cent and 10 per cent solutions), and with chloroacetophenone in lubricating oil (1 per cent and 10 per cent solutions) are inconclusive on account of lack of flies. Both chloroacetone and chloroacetophenone when used undiluted not only kept over 99 per cent of the flies away, but also prevented any emergence of Cochliomyia, and the former compound prevented all infestation.

ACIDS

Although the number of tests with organic acids is inadequate for generalizing, it appears that valeric acid is attractive to screw-worm flies.

ESTERS

The esters tested appear to be neutral rather than repellent to Cochliomyia and do not prevent infestation.

HALOGEN SUBSTITUTED ESTERS

Both the beta-chloroethyl and beta-bromoethyl acetates are quite effective in repelling screw-worm flies; and both are quite effective in preventing infestation, not only in undiluted form, but also in combination with lubricating oil (10 per cent solution). There was no emergence of Cochliomyia from any of the jars treated with these compounds. The bromo compound is a more effective repellent than the chloro compound. This is in harmony with the results obtained with para-xylyl chloride and para-xylyl bromide.

ETHERS

Beta-naphthylethyl ether is a very good repellent for use against screw-worm flies, being effective over four days' exposure. The tests with this compound mixed with petrolatum and with mineral oil were made when an insufficient number of flies was present for an accurate result. Beta-naphthylethyl ether does not prevent infestation. There was no emergence of Cochliomyia from these jars.

CHLOROHYDRINS

Only one compound belonging to this group, namely epichlorohydrin, was tested, and though very few flies were available at the time of the test, the compound exhibits no worth-while repellent action; neither does it prevent infestation.

NITRO COMPOUNDS

Nitrobenzene and alpha-nitronaphthalene were good repellents over the entire period of the test. Nitrocymene is an excellent repellent during the first two days' exposure, but loses its effectiveness on the third day. In preventing infestation, all the nitro compounds show up poorly. The emergence data with this group of compounds are incomplete, but no Cochliomyia emerged from meat treated with nitrobenzene.

MIXED NITRO COMPOUNDS

Picric acid, and chloropicrin in lubricating oil in dilutions of 1 in 10 and 1 in 25, are very effective repellents during five days' exposure. Chloropicrin in dilutions of 1 in 50 and 1 in 100 of lubricating oil are effective over the first and second days of exposure. Although the number of screw-worm flies available at the time the tests with para-nitroaniline were made was very small and no generalization can be made, this compound does not look promising for use as a repellent.

Picric acid is not of value in preventing infestation, but chloropicrin in dilutions of 1 in 10 and 1 in 25 of lubricating oil prevented all infestation and emergence.

AMINES

Dimethylaniline, both undiluted and in combination with petrolatum and kaolin, is a good repellent for the first two days of exposure only. One test with alpha-naphthylamine indicates that it has good repellent value over the entire five-day period.

Dimethylaniline is of little value in preventing infestation after the first day of exposure. The jar treated with alpha-naphthylamine was not infested till the fourth day. No Cochliomyia emerged from meat treated with any of the amines.

MISCELLANEOUS NITROGENOUS COMPOUNDS

Pyridine is a very good repellent against screw-worm flies, and although all 10 jars were infested by the third day, there was no emergence of Cochliomyia.

Nicotine sulphate is of no value either as a repellent or in preventing infestation.

SULPHUR COMPOUNDS

Ethyl mercaptan is one of the most strongly attractive compounds to screw-worm flies tested. The results with allyl isothiocyanate are not consistent; when diluted with either mineral oil, petrolatum, or kaolin it appears a stronger repellent than when undiluted. An interesting contrast between the action of compounds very similar in chemical constitution is shown by ethyl and butyl mercaptans. The ethyl compound is strongly attractive to the flies, the meat treated with it is infested as soon as the untreated meat, and Cochliomyia emerged from both of the two jars treated with it. On the other hand, butyl mercaptan is a pretty good repellent for the first two days of exposure, and though all the jars were infested on the second day, there was no emergence of Cochliomyia. There was no emergence of Cochliomyia from meat treated with allyl isothiocyanate, either.

SELENIUM COMPOUNDS

The data on these compounds are too few for generalization, but are indicative that the selenium compounds are repellent for the first day of exposure only, and have no action on infestation.

INORGANIC COMPOUNDS

Some of the inorganic compounds tested exhibit repellent action for a few days. For example, antimony trichloride is repellent for two days, bleaching powder for three days, copper sulphate for three days, and potassium sulphide for two days. Even the odorless and chemically inactive powder kaolin, for the first day of exposure, repels three-fourths of the screw-worm flies normally present. The strong repellent action of copper carbonate, which persists throughout the five days of exposure, is one of the most puzzling results obtained in the investigation, and required further testing. None of the inorganic compounds are effective in preventing infestation. No Cochliomyia flies emerged from jars treated with borax or lead acetate.

ORGANIC PRODUCTS

ESSENTIAL OILS

The following essential oils when undiluted exhibit a coefficient of attractiveness toward screw-worm flies of 10 or less: Star anise, 9.8; bergamot, 6; cade, 4.9; cinnamon, 10; citronella (Ceylon), 2.8; clove, 9.5; clove bud, 6.1; coriander, 5; rose geranium, 8; nutmeg, 9.7; pennyroyal, 9.3; spearmint, 7.6. Tests with Java citronella oil and also with citronella oil of unknown geographical origin show them to have only moderate repellent value (coefficients 75 and 19, respectively) so that the high repellent value found for Ceylon citronella oil requires confirmation. In addition to the above oils, camphor by-product, cassia, copaiba, cumin, fennel, hemlock, and sassafras exhibit good repellent action (coefficient about 10 or less) for the first and second days of exposure only.

None of the essential oils were successful in preventing infestation, but whether the infestation was by Cochliomyia or not is difficult to say because the emergence data are very meager. There was no emergence of screw-worm flies, however, from meat treated with the following oils: Star anise, bergamot, cade, camphor, cedar leaf, cinnamon, citronella, clove bud, nutmeg, pennyroyal, sassafras, or thyme.

FATTY OILS

Peach-kernel oil is a good repellent for the first two days of exposure only. None of the fatty oils prevents infestation.

MISCELLANEOUS VEGETABLE PRODUCTS

Clove powder, derris, and pyrethrum are effective repellents for the entire five-day period. Cinnamon powder is effective for the first two days, as are also sassafras bark and wormseed; and lupulin powder is effective over a three-day period. A single test with powdered deer-tongue leaves indicates that they have considerable repellent value.

Although clove powder, derris, and pyrethrum did not prevent infestation, this was by species other than the screw-worm fly, as there was no emergence of Cochliomyia from any of the jars treated with these materials. The alcoholic and kerosene extracts of pyrethrum also prevented emergence of Cochliomyia.

PINE PRODUCTS

Nearly all of the pine products are very good in repelling screw-worm flies. Although most of the meat treated with pine products showed infestation, this was by species other than Cochliomyia.

FURFURAL MIXTURES

All of the furfural mixtures are excellent repellents and are also effective in preventing infestation by Cochliomyia (but not by other species).

COAL-TAR CREOSOTES

The coal-tar creosotes are very effective in repelling screw-worm flies and also in preventing infestation by this species.

BONE MEAL

Bone meal repels five-sixths of the screw-worm flies normally visiting meat during the first day of exposure.

BEST REPELLENTS

The most effective repellents against the screw-worm fly are listed in Table 2 in the order of decreasing effectiveness. Only those materials whose coefficient of attractiveness is 10 or less, and in the tests of which not less than 100 flies visited the check jars, are considered. The infestation at end of fifth day and emergence data are also shown for each material in the table. It should be distinctly understood that these statements are not generalizations, but apply only to the tests herein described, and that under other conditions, especially when the substances are used on wounds, very different valuations might be obtained.

TABLE 2.—*Best repellents against Cochliomyia macellaria*

Material	Coefficient [1]	Number of treated jars	Number of flies in treated jars over checks	Infestation: Number of infested treated jars over checks	Emergence, treated over check jars
Salicylic aldehyde (1) plus petrolatum (5)	0	2	0:113	0:2	[2] 0:-
Chloroacetophenone	0	3	0:770	2:3	0:3
Chloroacetophenone (1) plus petrolatum (2)	0	1	0:455	1:1	0:1
Camphor oil by-product (1) plus bone meal (3)	0	1	0:455	0:1	0:1
Clove-bud oil (3) plus petrolatum (1)	0	1	0:455	1:1	0:1
Clove powder (1) plus petrolatum (2)	0	2	0:456	2:2	0:1
Wood naptha	0	4	0:160	4:4	0:2
Pine tar, heavy	0	4	0:160	4:4	0:2
Pine tar, medium	0	4	0:160	4:4	1:2
Pine tar, thin	0	4	0:160	4:4	0:2
Pine-tar oil, refined (1) plus petrolatum (5)	0	2	0:456	0:2	0:1
Pine-tar oil, refined (1) plus kaolin (3)	0	1	0:455	0:1	0:1
Pine-tar oil, commercial	0	10	0:491	8:10	1:6
Pine-tar oil, commercial (3) plus furfural (1) plus star anise oil (1)	0	2	0:302	0:2	0:2
Pine-tar oil, commercial (3) plus furfural (1) plus camphor-sassy oil (1)	0	2	0:302	0:2	0:2
Pine-tar oil, commercial (3) plus furfural (1) plus a creosote dip (1)	0	2	0:302	1:2	0:2
Pine-tar oil, commercial (1) plus furfural (1)	0	2	0:238	2:2	0:0
Pine-tar oil, commercial (10) plus furfural (1)	0	2	0:302	1:2	0:2
Pine-tar oil, commercial (20) plus furfural (1)	0	2	0:302	0:2	0:2
Pine-tar oil, commercial (3) plus furfural (1) plus fennel oil (1)	0	2	0:302	0:2	0:2

[1] The figures in this column correspond to those in column 6 of Table 1, i. e., percentage ratio for the entire period.
[2] The sign (-) means no record.

TABLE 2.—*Best repellents against Cochliomyia macellaria*—Continued

Material	Coefficient [1]	Number of treated jars	Number of flies in treated jars over checks	Infestation: Number of infested treated jars over checks	Emergence, treated over check jars
Pine-tar oil, commercial (3) plus furfural (1) plus safrol (1)	0	2	0:302	0:2	0:2
Pine-tar oil, commercial (3) plus furfural (1) plus artificial sassafras oil (1)	0	2	0:302	0:2	0:2
Pine-tar oil, commercial (3) plus safrol (1) plus camphor-sassy oil (1)	0	2	0:302	1:2	0:2
Pine-tar oil, commercial (3) plus safrol (1) plus fennel oil (1)	0	2	0:302	0:2	0:2
Pine-tar oil, commercial (3) plus safrol (1) plus salicylic aldehyde (1)	0	2	0:238	0:2	0:0
Pine-tar oil, commercial (3) plus salicylic aldehyde (1)	0	4	0:238	3:4	0:2
Pine-tar oil, commercial (3) plus safrol (1)	0	4	0:302	2:4	0:4
Pine-tar oil, commercial (10) plus safrol (1)	0	2	0:302	2:2	0:2
Pine-tar oil, commercial (20) plus safrol (1)	0	2	0:302	0:2	0:2
Furfural (2) plus pine-tar oil (3) plus zinc stearate (2)	0	2	0:505	2:2	0:2
Furfural (1) plus castor oil (1) plus grafting wax (2)	0	2	0:505	2:2	0:2
Wood-creosote oil	0	2	0:505	2:2	0:2
Coal-tar creosote (1) plus kaolin (3)	0	1	0:455	0:1	0:1
Pine-tar oil, refined	.10	9	1:999	9:9	0:5
Copper carbonate	.10	3	1:966	3:3	1:3
Para-xylyl bromide	.16	4	1:617	0:4	0:4
Chloroacetone	.16	6	1:634	0:6	0:6
Furfural (1) plus petrolatum (2) plus zinc oxide (1)	.20	2	1:505	2:2	1:2
Furfural (1) plus castor oil (1) plus rosin (1)	.20	2	1:505	2:2	0:2
Pine oil No. 4	.21	10	2:932	8:10	0:4
Furfural (1) plus petrolatum (5)	.21	3	1:475	1:3	0:1
Sassafras oil, artificial (1) plus kaolin (3)	.22	1	1:455	1:1	0:1
Clove-bud oil (1) plus kaolin (3)	.22	1	1:455	0:1	0:1
Coal-tar creosote (1) plus petrolatum (5)	.22	2	1:456	1:2	0:1
Pine oil, refined	.23	8	1:427	6:8	0:2
Camphor, artificial (pinene hydrochloride)	.27	1	1:366	1:1	0:1
Chloroacetophenone (1) plus kaolin (1)	.29	3	2:684	2:3	0:3
Beta-bromoethyl acetate	.32	4	2:617	1:4	0:4
Pine-tar oil (3) plus safrol (1) plus anise oil (1)	.33	2	1:302	1:2	0:2
Guaiacol	.40	2	2:505	2:2	0:2
Pine oil No. 4 (1) plus pine-tar oil (1)	.42	2	1:238	2:2	0:0
Coal-tar creosote	.41	3	4:982	0:3	0:3
Camphor oil by-product (3) plus petrolatum (1)	.3	4	3:1,023	2:4	0:2
Rosin residue (1) plus pine oil (1)	.59	2	3:505	2:2	0:2
Pine tar (1) plus borax (1) plus kaolin (2)	.66	1	3:455	1:1	0:1
Pine-tar oil (3) plus safrol (1) plus artificial sassafras oil (1)	.66	2	2:302	1:2	0:2
Iodoform (1) plus petrolatum (2)	.66	1	3:455	1:1	0:1
Benzyl chloride	.81	4	5:617	0:4	0:4
Clove oil (3) plus petrolatum (1)	.88	2	1:113	2:2	----------
Clove powder (1) plus kaolin (4)	.88	1	4:455	1:1	0:1
Pine oil (steam distilled)	.99	2	5:505	2:2	0:2
Pine-tar oil (3) plus furfural (1)	1.0	4	3:302	3:4	1:4
Allyl isothiocyanate (1) plus kaolin (3)	1.1	4	7:640	4:4	0:1
Sassafras oil (3) plus petrolatum (1)	1.6	3	9:568	3:3	0:2
Pine-tar (1) plus borax (1)	1.6	3	11:688	2:3	0:1
Pine oil No. 4 (1) plus refined tar oil (1)	1.7	2	4:238	2:2	0:0
Pine-tar oil (1) plus safrol (1)	1.7	2	4:238	2:2	0:0
Pine-tar (1) plus borax (1) plus petrolatum (2)	1.5	1	7:455	1:1	1:1
Pine-oil foots (1) plus furfural (1)	1.8	2	9:505	2:2	0:2
Wood-tar oil	1.4	6	9:625	4:6	0:0
Furfural (1) plus gum galbanum (1)	1.2	2	6:505	2:2	0:2
Picric acid	2.0	3	19:966	3:3	2:3
Benzaldehyde	2.2	2	11:505	2:2	1:2
Nitrobenzene (1) plus kaolin (4)	2.3	3	14:623	3:3	0:1
Chloropicrin (1) plus lubricating oil (24)	2.3	2	14:600	0:2	0:2
Pine oil, crude	2.3	2	14:616	2:2	1:2
Pine-tar acid	2.4	2	12:505	2:2	1:2
Nitrobenzene (1) plus petrolatum (5)	2.4	2	13:551	2:2	0:1
Iodoform (1) plus kaolin (4)	2.6	1	12:455	1:1	0:1
Alpha-naphthylamine	2.6	1	4:151	1:1	0:1
Clove oil (1) plus kaolin (3)	2.7	2	3:113	2:2	----------
Citronella oil (Ceylon)	2.8	3	6:212	3:3	----------
Turpentine ,crude	2.8	7	21:747	7:7	1:5
Furfural (1) plus petrolatum (1) plus grafting wax (2)	2.0	2	11:505	2:2	0:2
Camphor oil by-product (1) plus kaolin (3)	1.7	5	19:1,095	2:5	0:2
Furfural (1) plus petroleum (1)	3.2	2	16:505	2:2	0:2
Furfural (1) plus kaolin (4)	3.6	4	23:640	3:4	1:1
Beta-chloroethyl acetate	3.6	4	22:617	1:4	0:4

[1] The figures in this column correspond to those in column 6 of Table 1, i. e., percentage ratio for the entire period.

TABLE 2.—*Best repellents against Cochliomyia macellaria*—Continued

Material	Coefficient[1]	Number of treated jars	Number of flies in treated jars over checks	Infestation: Number of infested treated jars over checks	Emergence, treated over check jars
Pine tar	3.9	16	93:2,373	11:16	0:6
Beta-naphthylethyl ether	4.0	9	60:1,506	7:9	0:6
Pine-tar oil	4.4	12	35:798	12:12	0:3
Powdered deer-tongue leaves	4.4	1	16:366	1:1	1:1
Clove powder	4.7	12	71:1,502	9:12	0:4
Pyridine	4.7	10	68:1,447	10:10	0:4
Derris powder	4.7	5	30:634	5:5	0:4
Safrol (1) plus kaolin (4)	4.8	2	8:168	2:2	0:–
Cade oil	4.9	11	59:1,207	11:11	0:6
Salicylic aldehyde (1) plus kaolin (4)	4.9	3	9:185	2:3	0:–
Coriander oil	5.0	7	67:1,331	6:7	1:4
Furfural	5.3	17	81:1,527	16:17	0:7
Pyrethrum powder	5.8	6	50:862	6:6	0:6
Bergamot oil	6.0	1	22:366	1:1	0:1
Clove-bud oil	6.1	5	54:893	5:5	0:2
Citronella oil (Ceylon) (3) plus petrolatum (1)	6.2	2	7:113	2:2	----------
Citronella oil (Ceylon) (1) plus kaolin (3)	6.2	2	7:113	2:2	----------
Crotonaldehyde	6.4	4	23:357	4:4	0:4
Pine oil, pure steam distilled	6.5	8	42:647	4:8	1:4
Alpha-nitronaphthalene	6.6	1	10:151	1:1	1:1
Iodoform	6.8	4	76:1,116	4:4	0:4
Alpha-bromonaphthalene	7.1	5	67:941	5:5	0:3
Wood creosote	7.5	7	35:465	6:7	0:1
Spearmint oil	7.6	9	119:1,561	9:9	1:6
Star-anise oil (1) plus kaolin (3)	8.0	2	9:113	2:2	----------
Rose-geranium oil	8.0	5	91:1,136	4:5	1:4
Pine oil, pure amber steam distilled	8.3	3	51:617	2:3	0:2
Pennyroyal oil	9.3	11	206:2,209	5:11	0:2
Clove oil	9.5	10	105:1,107	9:10	1:3
Wood naptha (1) plus pine-tar oil (1)	9.6	2	19:198	2:2	0:0
Nitrobenzene	9.6	16	132:1,378	13:16	0:5
Nutmeg oil	9.7	2	15:154	2:2	0:1
Star anise oil	9.8	11	142:1,456	7:11	0:4
Hexachloroethane	10	2	16:154	2:2	1:1
Cinnamon oil	10	12	196:1,969	10:12	0:4

[1] The figures in this column correspond to those in column 6 of Table 1, i. e., percentage ratio for the entire period.

These best repellents may be classified in the following groups:

Halides. Benzyl chloride, para-xylyl bromide, iodoform, hexachloroethane, alpha-bromonaphthalene.

Phenols. Guaiacol.

Aldehydes. Furfural, benzaldehyde, salicylic aldehyde.

Chlorine substituted ketones. Chloroacetone, chloroacetophenone.

Halogen substituted esters. Beta-bromoethyl acetate, beta-chloroethyl acetate.

Ethers. Beta-naphthylethyl ether.

Nitro compounds. Nitrobenzene, chloropicrin (trichloronitromethane), picric acid (trinitrophenol), alpha-nitronaphthalene.

Amines. Alpha-naphthylamine.

Miscellaneous nitrogenous compounds. Pyridine.

Inorganic compounds. Copper carbonate.

Essential oils. Clove-bud oil, artificial sassafràs oil, clove oil, Ceylon citronella oil, cade oil, coriander oil, bergamot oil, spearmint oil, star-anise oil, rose-geranium oil, pennyroyal oil, nutmeg oil, cinnamon oil.

Miscellaneous vegetable products. Pyrethrum, derris, clove powder, powdered deer-tongue leaves.

Pine products. Pine oil, pine tar, pine-tar oil, turpentine, etc.

It will be noted that one of the halides (alpha-bromonaphthalene), the only ether studied (beta-naphthylethyl ether), one of the nitro compounds (alpha-nitronaphthalene), and the better of the two amines studied (alpha-naphthylamine) are all naphthalene derivatives. Naphthalene itself was tested at times when too few screw-worm flies were present to enable a conclusion to be drawn.

The following compounds were used during the World War as "tear gases" and are characterized by causing intense irritation to the eyes: Benzyl chloride, para-xylyl bromide, chloroacetone, chloroacetophenone, beta-chloroethyl acetate, beta-bromoethyl acetate, and chloropicrin.

In regard to attractiveness for the screw-worm fly, ethyl mercaptan was the best in this respect. Chloroform shows some attractiveness, also denatured alcohol and valeric acid.

Practically all of the materials which are effective in repelling screw-worm flies are also very effective in preventing the deposition of eggs. The emergence data show that almost no Cochliomyia emerged from any of the jars treated with these repellents. In other words, the fly-repellent value of a material is an index of its value in preventing infestation by Cochliomyia.

MATERIALS EXHIBITING A PERFECT REPELLENT ACTION FOR PERIODS OF FROM TWO TO FIVE DAYS

Each of the following materials was tested not less than four times, and when the number of flies visiting all the comparable check jars was 100 or over:

(1) Materials which repelled all flies for a period of two days: Allyl isothiocyanate plus kaolin, and cade oil.

(2) Materials which repelled all flies for a period of three days: Pine-tar oil, refined.

(3) Materials which repelled all flies for a period of four days: Para-xylyl bromide, refined pine oil, and pine oil No. 4.

(4) Materials which repelled all flies for a period of five days: Wood naptha, heavy pine tar, medium pine tar, thin pine tar, commercial pine-tar oil, commercial pine-tar oil (3) plus safrol (1), commercial pine-tar oil (3) plus salicylic aldehyde (1).

Inasmuch as both allyl isothiocyanate and fennel oil, when applied undiluted to meat, failed to keep all screw-worm flies away for the first two days, it is probable that additional tests with mixtures of these compounds with kaolin and petrolatum will indicate that they have less repellent value than present tests show.

The above grouping of materials is of interest because it is the experience of stockmen that a material which effectively repels flies for at least two days is suitable for use on animals as a fly-repelling wound dressing, provided, of course, there are no practical objections to its use, such as injurious effects on the animal tissues.

RELATION BETWEEN REPELLENT ACTION OF COMPOUNDS AND THEIR CHEMICAL CONSTITUTION AND VOLATILITY

An examination of the data fails to show any consistent relation between the fly-repellent properties of the compounds and their chemical constitution. There is no clear difference in the repellent action of the aliphatic and aromatic compounds, nor in that of the various classes of compounds, such as aldehydes, phenols, etc.

The introduction of a halogen atom into a compound in some cases greatly increases its repellent action toward screw-worm flies. For example:

Compound	Coefficient	Compound	Coefficient
Toluene	68	Benzyl chloride	0. 8
Dextro-pinene	58	Pinene hydrochloride	. 27
Naphthalene	65	Alpha-bromonaphthalene	7. 1
Acetone	76	Monochloroacetone	. 16

On the other hand, in some cases the halogen derivative has almost the same repellent value as the parent hydrocarbon. For example:

Compound	Coefficient	Compound	Coefficient
Crude solvent naphtha (mixture of xylenes)	22	Para-xylyl chloride	16
Naphthalene	65	Chlorinated naphthalene	60
Benzene	70	Para-dichlorobenzene	82

Bromine has a more marked action in enhancing the repellent action of a compound than chlorine. For example:

Compound	Coefficient	Compound	Coefficient
Para-xylyl chloride	16	Para-xylyl bromide	0. 16
Beta-chloroethyl acetate	3. 6	Beta-bromoethyl acetate	. 32

Iodine is even more powerful than bromine in increasing the repellent action of compounds. Compare:

Chloroform, 192; bromoform, 51; iodoform, 6.8.

The introduction of a nitro (NO_2) group into a compound increases its repellent action toward screw-worm flies. For example:

Compound	Coefficient	Compound	Coefficient
Benzene	70	Nitrobenzene	9. 6
Para-cymene	46	Nitrocymene	39
Naphthalene	65	Alpha-nitronaphthalene	6. 6
Chloroform	192	Chloropicrin (nitrochloroform)	0

There is no correspondence in the repellent action of the compounds tested and their boiling points. While in the homologous series benzene, toluene, and ortho-xylene an increase in boiling point is accompanied by an increase in repellent action upon screw-worm flies, this is so slight as to be within the limit of error in the results.

	Boiling point (° C.)	Coefficient
Benzene	79. 6	70
Toluene	110. 5	68
Orthoxylene	144	47

The following examples show how little relation there is between the repellent action and boiling points of compounds:

	Boiling point	Coefficient
(1) Compounds boiling between 142.5° and 161.7° C.:		
Amyl acetate	142. 5	75
Allyl isothiocyanate	150. 7	16
Alpha-pinene	154	58
Furfural	161. 7	5. 3
(2) Compounds boiling between 202° and 220.7° C.:		
Normal-caproic acid	202	35
Guaiacol	205. 1	0. 4
Citronellal	208	45
Camphor	209. 1	29
Nitrobenzene	210. 9	9. 6
Menthol	212	98
Dextro-borneol	213. 5	13
Naphthalene	217. 9	65
Alpha terpineol	219. 8	12
Para-xylyl bromide	220. 7	0. 16

Obviously the boiling point would have a relationship to the persistence of the repellent effect, and materials with a very low boiling point would be too volatile to be of practical value as repellents.

SUMMARY

In an investigation having as its object the discovery of a repellent for blowflies suitable for application upon wounds on domestic

animals, the chemotropic responses of three species of blowflies (the screw-worm fly, *Cochliomyia macellaria* Fab.; the green-bottle fly, *Lucilia sericata* Meig.; and the black blowfly, *Phormia regina* Meig.), and the house fly (*Musca domestica* L.) to a wide range of organic and inorganic compounds, essential oils, plant products, and pine-distillation products have been determined.

The repellent or attractant action of 353 compounds and mixtures upon the screw-worm fly, *Cochliomyia macellaria* Fab., is reported in this bulletin.

The chemotropic effect of these materials was tested by smearing 5 cubic centimeters of the liquids or 5 grams of the solids over 4 ounces of fresh beef liver contained in a pint Mason jar. These jars were then exposed in the proximity of a packing house or other environment where flies were abundant. Tests were made at Dallas and Uvalde, Tex., during the summer months. Untreated meat was exposed at the same time, and the chemotropic effect of the materials is calculated by the ratio of the number of flies visiting the treated jar over the number of flies visiting the untreated or check jar. A total of 1,152 treated jars are reported in this bulletin.

About 20 of the organic compounds diminish the normal attractiveness of beef liver to Cochliomyia flies from 100 to 10 or less. These are representative of nine different classes of organic compounds. Four of these compounds are naphthalene derivatives, and seven others are characterized by causing intense irritation to the eyes of man, and were used during the World War as "tear gases." There are not sufficient data on the organic compounds to show clearly any consistent relation between chemical constitution and repellent value. There appears to be no relation whatever between the repellent action of the organic compounds tested and their boiling points.

Only one inorganic compound, copper carbonate, is an effective repellent for screw-worm flies. A number of the essential oils are good repellents, among which are Ceylon citronella oil and American pennyroyal oil, commonly used as mosquito repellents. Powdered pyrethrum and derris, both of which are valuable contact insecticides, are effective in repelling screw-worm flies.

Except for the conclusion presented in the following paragraph, no attempt is made to draw conclusions as to the practicability of utilizing on livestock the substances tested. The results herein presented serve as a basis for tests on living animals, which are now under way. Furthermore, it is felt that these studies are a step in the direction of obtaining a better insight into the fundamental principles underlying the chemotropic responses of insects.

Of all the materials tested as repellents against the screw-worm fly, certain products obtained from the pine are among the best. These include pine oil, both the destructively and steam distilled, crude turpentine, pine tar, and pine-tar oil. In view of the cheapness, availability, nontoxicity, and adhesiveness of pine-tar oil, the writers are of the opinion that this is the best material among all of those tested to use upon wounds of domestic animals to protect them against the screw-worm fly.

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